ENTERIC FEVER

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ENTERIC FEVER
IN INDIA
AND IN OTHER TROPICAL AND SUB-TROPICAL REGIONS

A Study in Epidemiology and Military Hygiene

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To E.

Dare quam accipere! In giving you this book I take your name, that one page may shine with the symbol of grace and truth and perfect service.

PREFACE.

"*Seu vetus est verum diligo sive novum*" must be the watch-words of the Epidemiologist and of him who ventures into the perilous paths of Vital Statistics. It is possible that some will accord a somewhat chill reception to an appeal made from these stand-points ; there is a tendency to regard the Epidemiologist as one who has performed good service in by-gone days before what are called exact methods of research were instituted,* but who now lags superfluous on the stage ; while, on the other hand, the Vital Statistician is at best a dry and doubtful counsellor who seeks to obtain the figs of truth by the assiduous cultivation of the thistles of error.

But it is scarcely necessary to make a serious attempt to refute these misconceptions ; if at any time they concealed a modicum of truth in regard to either of the spheres of work taken separately, the obvious answer is that these stand or fall together, one being the inalienable complement and corrective of the other. With the advance of medicine and hygiene, the development of the science and art of bacteriology, along with the growth of the materials for, and the improvement in the methods of utilizing, Vital Statistics, the Epidemiologist now finds a more important and, indeed, an indispensable *rôle* in the combat with disease with the new and more precise weapons thereby placed at his disposal. He alone, indeed, can combine and direct the various forces working in the different spheres and, while utilizing the fruits of these labours, is in the best position to define the lines of advance and the points for fresh attack. To him especially are the privilege and the responsibility committed of following the scientific method, by formulating hypotheses of the uniformity of Nature on the assumption of the harmony and intelligibility of natural processes, and thus of binding new knowledge to the old by links of rational theory and of working hypothesis. If he perform no higher function than that of outlining our ignorance, he will still promote the first step of advance.

*Simon, the great Master himself, said: "the doctrines promulgated by the older sanitarians on the subject of infection have long since been made obsolete by the advances of exact knowledge."

But for this, he must not only be equipped in the science of Medicine, but must master also the principles and the established facts of Biology in general, and of Vital Statistics in their biological bearing in particular. As a recent writer has declared truly, "the problems of evolution and heredity have not greatly interested the majority of medical men"; they have lived and worked without due regard to the labours and interests of biologists,—botanists and zoologists,—and this is largely due to a hiatus in the curriculum of the schools and to the nature of their after life-work, which tends to restrict their view to the individual. The problems of Enteric Fever might possibly be deemed to lie wholly within the province of the medical man and the sanitarian, but, as will be seen, this is to overlook altogether some of the most important considerations involved. To refer to one aspect only, *viz.*, the historical, and that in connexion with both man and the microbe, we may adapt the dictum of Lord Acton and affirm that there can be no philosophy founded on the observations of 40 years to the exclusion of the teaching of as many thousands.

Again, Statistics are, taken truly, simply organized symbols of experience which is, after all, the guide of life; responsibility is founded upon such order as we can observe, and not upon such disorder as we can conjecture. That they may be abstract compromises that do not exactly represent the truth in any particular event may be conceded, and yet their indispensable value as generalisations is not to be denied. They give shape to what is hidden, if only as the shadow of the truth; they declare truth, if only at times in parable. "Reason's steady light" itself may be refracted by an ignorant or impious mind into the alluring rainbow hues of error, but it is the Statistician's business to employ the scientific method, the life-principle of which is a contest with error to which dogma and superstition give a charter. Then truly may it be said of Statistics that they are like........

> .... "*double mirrors making still*
> *An endless vista of fair things before,*
> *Repeating things behind.*"

To revert from the ideal to the actual performance herein attempted, the writer would observe that it has no pretensions to higher authority, wider scope or finality than that which may be claimed for an Essay, *i e.*, a *weighing* or *testing* of evidence and the formulation of a hypothesis by which the facts can best be explained. In the course of the argument certain fundamental principles, biological and pathological, are enunciated and an endeavour has been made to demonstrate their application to the elucidation of all epidemiological problems, and in this sense the work may be considered a contribution to Tropical Medicine and Hygiene in general; the discourse travels beyond the text with results which it is hoped will justify a precedent not always held in high esteem. No one can be more conscious than the writer of the failure to fulfil his precepts and to rise to the height of his argument; and as to that, he can only cherish the hope that there may emerge "sufficient light for us in the dark to rise by",—and that we may rise.

For the form of its presentation, the literary garment, so far from resembling the purity and beauty of a "resurrection robe", it can only be pleaded in extenuation that the book has been written in detached hours and half-hours of the fragmentary leisure of an official life that takes full toll of all one's time and energies and does not foster the pursuit of art for art's sake. There are occasions on which the very stones will cry out, with no regard to the music of their utterances; the first duty that fell to the writer's lot as an army surgeon was to make a *post-mortem* examination of the body of a British soldier who had died of Enteric Fever; the hospital wards were full of cases of the disease, and the sense of responsibility for failure then aroused has grown more and more acute with subsequent experience.

When this book was projected little change had occurred in the main conceptions of the etiology of the disease which had dominated opinion in India during the course of the 17 years of the writer's service. Good work was being done in nearly all directions, but it failed of its effects, chiefly because the sources of infection within cantonment limits were, in certain essential respects, overlooked, while the natives were regarded as "saturated with the infection," and, consequently, as nullifying the efforts put forth. It will be seen that, apart from any conclusion which may be arrived at on the specific question of the extent and influence of native infection, the main contention of this essay is to establish the fact of the pre-eminence of the intra-cantonment *foci* as factors in the lamentable prevalence of the disease. And this has since been recognized by the Authorities, who are now directing their attack upon the primary and proximate sources of infection.* While this is so, the battle cannot yet be deemed won, for these newer methods are still in the experimental stage; there

*The record for 1905, as yet unpublished, would appear to afford promise of fruitful results in the near future and to lend support to the views to be advocated in the following pages is still much to be learnt in regard to their scientific and economic application as well as to their extension on an organic plan based on a fuller examination of all the etiological factors. We have therefore to revise, to amplify and to justify our methods from the standpoint of a truer and more complete conception of the problem, and to this end this contribution has been made in the confidence that it will not be made in vain, inasmuch as it may invoke a special sanction at a turning-point in the course of opinion. It gives the writer, therefore, the greater pleasure, as it has afforded the highest incentive, to obey the precept :—

> " *Vor den Wissenden sich stellen,*
> *Sicher ist's in allen Fällen !*"

But no apology is offered in regard to the theme and object of the work. We find, in comparing the statistics for the army located in the United Kingdom with those for the European troops in India, that the hospital admission and constantly-sick rates are approximately twice as great, and that the death-rate is nearly three and a half times as great among the latter body. On the other hand, the invaliding-rate (for final discharge from the service) is slightly higher in the Home army, which would appear to indicate that the *personnel* in India is of superior quality in regard to physical stamina. If the causes of inefficiency and loss be analyzed it will be found that the contrast, so disadvantageous to the Indian army, depends, so far as sickness is concerned, almost entirely upon the greater incidence of fevers which are referred to the category of malarial infections, and of venereal diseases. But the most striking feature of the returns is the demonstration that the irredeemable and excessive loss by mortality in India is due to the small class of diseases to which a " filth " origin may be attributed, *viz.*, Enteric Fever, dysentery, diarrhœa and bowel disorders in general, and their sequelæ. If we disregard the excess of a little over 1 *per mille* on account of "injuries," we have, in the fatal operation of these causes, an almost complete explanation of the higher mortality in this country, to the total of which they contribute considerably more than one-half. During the last decade of the nineteenth century, 6,250 deaths were recorded from these specified causes alone, Enteric Fever being credited with 4,250, against 4,230 for *all other* causes combined, and, as will appear in the sequel, this class of "filth" diseases has defied all efforts to control and reduce it to any appreciable extent, during the forty years that followed the inauguration of the sanitary era under the auspices of the Royal

Commission of 1863. This then is the blot on an otherwise remarkable record of progress and it is to an examination of the causes of our failure that the following pages are addressed in the hope of establishing the principles upon which alone rational and fruitful methods of prophylaxis can be based.

The hardest task remains—to acknowledge adequately all who have so generously responded to enquiries and who have given of the fruit of their experience. The writer can claim little more for himself than the endeavour to prove all things in connexion with the subject, and to link the old truths with the new in their due relation; for the rest he has not scrupled to take his good things wherever they were to be found. The Annual Reports of the Sanitary Commissioner (India) have been the richest quarry, and indeed, they are, in a very literal sense, the "onlie begetters" of this book, though it is necessary to add that the writer alone is responsible for the inferences drawn and for the opinions expressed as a result of his study of the 35 volumes. It may also be said in this place, that no attempt has been made to present a complete bibliography of the subject, partly because it would fill a volume by itself, but chiefly because there is nothing to compare with the Sanitary Commissioner's Reports in this respect, and these are readily available to all Army Medical Officers. The Reports of the Army Medical Department have similarly been laid under contribution to an extent which will be apparent in the sequel; comment on the value of these records would be equally superfluous and impertinent, but the writer cannot forego the opportunity of expressing his grateful acknowledgments to the Principal Medical Officer, His Majesty's Forces in India, and his Staff for their courtesy and generosity in furnishing materials of the greatest interest and value. In all the more personal services rendered the authority has been quoted in the text, but the writer desires to thank all his colleagues, official and unofficial, for their generous help, bestowed in most cases at great sacrifice of scanty leisure : there is scarcely one out of hundreds, who has not acted up to the good doctor's motto : "*dare quam accipere*," and apart from the value of their contributions they have displayed the distinctive virtue of our profession.

The writer owes a special tribute of gratitude to his friend, Babu Fakir Chand, of the Statistical Branch of the Sanitary Commissioner's Office, who has extracted the data for the great majority of the Tables, Charts and Diagrams from the Records, both published and unpublished, and also for an enormous amount of compilation deemed necessary in the pursuit of clues which led only to disappointment. In no sphere of work is so much bread cast upon the waters with so little prospect of finding it even after many days. It need scarcely be added that the writer takes all responsibility for the facts and figures quoted in his own argument, he having checked them and put them into their present forms throughout.

Finally, there are obligations which the writer owes to the reader and which may be met to some extent by an exposition of the point of view from which the problem has been approached A philosopher who has devoted his life to the study and teaching of medicine has exclaimed with equal ardour and insight : "I am sick of diseases; I want to know origins and processes. The pathology of processes is the work of the future. If we are to prevent disease, it is to the beginning of the chain of accumulating stresses that we must look." (Prof. Clifford Allbutt.) Elsewhere he has pointed out that health itself is only the more perfect balance of a moving equilibrium ; that life in the healthy involves the incessant repair of decay ; that the normal for one individual is the abnormal for another and that the gradations between health and disease are infinite. Disease, on this view, is a particular state of the individual, but at the same time there is an underlying unity in all forms it may assume ; and thus while each kind of plant or animal presents certain morbid manifestations peculiar to itself, these manifestations have certain features in common. The ultimate factor which determines the "specificity" of a disease is the nature of the medium involved in the process—the tissue cells of the patient—as is seen for example in the case of small-pox and cow-pox, which are due to what is called the same "cause", with results so different (and indeed mutually exclusive) as to obscure for so long, their identity of origin. With a fundamental unity in all morbid processes there are notable differences in the manifestations of each disease, owing to the fact that no two individuals of a species are precisely identical ; and this applies with greater force to different races.

On the other hand, the bacteriological doctrine of the specificity of disease "causes" has led to a rigid differentiation and classification of microbes on the basis of botanical genera and species as applied to multicellular organisms, a provisional expedient which ignores the primitive origin, the function and vital processes of the unicellular bacteria.

Thus in regarding the reaction which we call disease (and we are dealing with the "infections") we have been beguiled on the one hand into narrow conceptions by the assumption of the identity of the structure and function, and of the vital and chemical properties, of the tissue cells (the media) of all individuals of a given race; and by the acceptance of the doctrine of the immemorial "specificity" of the agents which provoke the reaction, on the other hand. There is further the double fallacy of considering these agents the "causes" of the diseases with which they are associated and of identifying the disease with the "cause." The element of truth in these propositions has led us out of the darkness and chaos of the old pathology, but it has come to exceed its prerogative and we have now to recognize its limitations and to readjust its weight in the light of fuller knowledge.

Physiological function and pathological reaction are essentially manifestations of the same forces in different degrees; they are both prefigured in the molecular properties of the cell, *i. e.*, in the potential energies of protoplasm; and from these, kinetic energies are only evolved under the influence of stimuli, functional (nutritional) and pathogenic. Hence we recognize a relation between vital function—nutrition and propagation—and the reaction we call disease, and this in regard to both tissue cell and bacterium. Pathological reaction is but perverted function in adjustment to the medium or environment.

Hitherto we have regarded, too exclusively the *corporate* organism of the host on the one side and the pathogenetic stimuli as "specific" entities on the other side. A truer conception of the reaction (disease) will be gained if we consider the crux of the process at the beginning of the stresses in which the ultimate tissue elements are involved, though it is not suggested that we should confine our view thereto. The tissue cells cannot be dissociated from their environment, anthropic (*i e.*, the rest of the organism) and ectanthropic, from which the various stimuli arise, both physiological and pathogenetic. And in regard to bacteria, they must be regarded as the substratum which determines the results of the reaction, which is in keeping with the facts of the biology of these microbes, as established by laboratory research. And on the other hand we cannot adopt the assumption of the immemorial "specificity" of the pathogenic bacteria; looking to the origin and function of these lowliest organisms with the gradations through every degree from pure saprophytism to conditional and to obligatory parasitism, we must postulate some common ancestral forms, from which *nutritional* varieties have been evolved in the struggle for existence. For our present purpose the interest centres chiefly in the functional attributes of the agents of putrefaction as concerned in the dissociation of the albuminous molecule which prefigures the pathogenetic action of the so-called "filth" bacteria. These faculties are the same in essence and subserve nutritional ends under different conditions. After all, for man, animal, plant and microbe, life centres round the struggle for Nitrogen. Nothing has emerged more clearly from the study of the biology than the fact of the close affinity between the pathogenetic agents of filth diseases and the agents of putrefaction, and we cannot but postulate the derivation of the former from the latter, which existed and performed their functions long before man (the essential stage for the former) appeared upon the scene. But in the original function the fundamental phenomena of parasitism are foreshadowed, and the sequence is easily followed from putrefaction in external nature to that within the intestinal tract of the lower animals and of man,—a process still truly ectanthropic,—and then with the change of environment and the necessity of adaptation thereto different degrees of parasitism, conditional and facultative, could certainly be evolved; and thus the groups with transition forms (as we have them in the Typho-Coli series) must have become established with the growth of population and of civilization.

The quality or kind of the reaction depends upon the nature (chemico-vital capacities) of the tissue or organ attacked; the quantitive distinction depends on the nature and power of the stimulus (microbe). That is why we cannot distinguish between the true Enteric and the Paratyphoid reactions, though the organisms are not the same; why also we are debarred from speaking logically of "types" of disease; why "pathogenic" bacteria do not always excite disease; why the reaction varies according tothe tissue involved and why all individuals (ages and sexes) and all races are not equally affected. The fact that a given microbe is always associated with a certain reaction (or symptom series) denotes rather the "specificity" of the medium, a similarity in the character of the tissue-cells of the hosts and a similarity in their life conditions: a proposition which is the root and justification of a rational system of hygiene.

The position will be rendered clearer by an adaptation of Johannes Müller's law of the "specific energy of the senses"; the same stimulus acting on different tissues or organs always produces different effects, while different stimuli acting upon the same tissue will provoke a similar reaction; the issue is determined chiefly by the potential energies of the cells affected. These potential energies are to be regarded as a complex of passive susceptibilities and active propensities which may be developed or suppressed by the influence of the environment (experience).

Next, in dealing with the problems of infection and immunity two or three fundamental considerations must be kept in view, *viz.*, first, that in the case of unicellular organisms (tissue cells and bacteria alike) characters acquired under the influence of the environment are certainly transmitted under the very favourable conditions of a rapid sequence of generations; and, second, that the phenomena of infection and immunity are simply correlates based on the same function of adaptation, as is shown by the effects of the so-called vaccines (attenuated cultures), in the results of which the tissue cells again play the predominant *rôle*. And, further, we know that, as a general rule, each variety of parasite has a special affinity with a particular tissue of the host. These propositions, which have a vital connexion with those previously adduced, may lead us to conclusions beyond the pale of the orthodox position of to-day, as we shall see when we come to a comprehensive, and at the same time closer, survey of the facts. But this is not a consideration that should fetter our judgment; the deeper and fuller truth is often only attained by the rejection of acquired conceptions, of custom and tuition; it may even involve a partial return to more primitive conceptions and sources of inspiration, for in science as in art a fruitful renascence may well follow the order *reculer pour mieux sauter.*

Such then in brief disjointed sketch is the thesis, to the test of which the facts are to be submitted, but with no attempt to coerce the reader's judgment. And, after all, the purpose and end of medical studies lie in action, and by this supreme test our thesis stands or falls. We have to recognize an intrinsic predisposition or a correlated "resistance" which varies in the different tissues and organs of the same individual, in different individuals of the same race and, *a fortiori*, in the different races of men. We see these variations subject to the influences of age and sex, of climate and season and of the general conditions of life—food, climate, civilization and the most prevalent forms of disease; but everywhere and always the end is towards more perfect adaptation to these conditions. We are unable to appraise the relative importance in this process of heredity and of the external conditions connoted by the term environment, in its broadest sense. The exposure of generation after generation to an almost identical environment, may account for much that is often ascribed to heredity. But the practical indication is clear; the overt manifestations of failure would alone supply the clue to the direction our efforts must take. We must enlist all the resources of adaptation and so influence favourably the potential energies, the dispositions, of men by the promotion of suitable external conditions—of personal and public hygiene. This defensive attitude, the tactics of fortification, provides the most effective method of attack against the pathogenetic stimuli by abolishing the conditions which favour their propagation and dissemination. For, as Hueppe has put the case with philosophic insight, the rational method of prophylaxis is to make the house fire-proof, rather than to dissipate effort in the extinction of sparks. The latter plan is well illustrated in the routine scattering of so-called disinfectants, whereas cleanliness is the better part of true disinfection, and, consequently, the sure way and the essential end of hygiene.

Hitherto our resources and efforts have been directed to the maintenance of our hospital services,—to the treatment of the sickness which we can and must prevent if the medical service is to fulfil its first and fundamental function ; and nothing short of a radical reorganisation and tactical redistribution of our resources will redeem the false situation created by the primitive conception of our duty which has survived from a pre-scientific era. In brief, a Sanitary Service must be organised, the scope and powers of which must be commensurate with the responsibility laid upon it, and to this end there must be perfect co-operation between the specialist in the various grades of the service and the whole body which it serves and for which it exists. No attempt to establish an independent providence arbitrarily divorced from the effectual source and exercise of its power—in the counsels of the administration and in the instructed intelligence of the individual units—will avail. This is emphatically a matter of national moment in which there must be no compromise, and no preventible opening left for the triumph of a better over the best attainable. And, fortunately, it is of good augury that we can invoke the authority of the statesman who now presides over the destinies of the army: "to-day science is essential to victory whether the struggle be in the arts of war or in those of peace."

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(With 30 Charts, Diagrams and Maps, and over 80 Tables in the Text.)

ENTERIC FEVER.

CHAPTER I.

INTRODUCTORY.

It is unnecessary to urge the importance of the subject which it is proposed to discuss in the following pages. The health of an army is the first condition of its efficiency, and the object of this Essay is to elucidate the causes of the most serious item of loss in the account which, as stewards of the national economy, we have to render. Enteric Fever, for all practical purposes, may be classed, to use Simon's phrase, with the other specific diseases of the bowels, cholera, dysentery and epidemic diarrhœa, as a "filth disease;" it has long been recognized as the opprobrium of communities living under conditions in which the first elements of sanitary law have been neglected, and it is therefore significant that it has come to occupy a predominant place in the vital statistics of armies in peace and war. While the loss from sickness, direct and indirect, from this cause is indeed formidable, it is the extent of the mortality, the actual elimination of men in the prime of their physical powers, which arouses the gravest concern and which renders a full and scientific investigation of the subject imperative. Until within recent years this aspect has been obscured in India by the preponderating incidence of other specific diseases, which operated in at least two ways; the much higher death-rate at all ages, and especially in the later ages, in former times, served to mask the special liability of the younger men to a form of disease which was not recognized as a specific entity, but which now stamps the vital returns with its characteristic incidence; and, secondly, it is probable that many susceptible subjects were eliminated by those other so-called tropical diseases, the suppression of which to a greater or less extent, has left Enteric Fever in its predominance. But, beyond this, as will be shown, there is cogent evidence of a very real increase in the prevalence of the disease.

It may serve to emphasize the practical bearing of the problem if we summarize a very few of the salient facts regarding the loss incurred by this one cause. Among the troops located in the United Kingdom, the average ratios *per mille* of strength of admissions to hospital (*i.e.*, cases of Enteric Fever) for the decade 1892-1901 were 1·3, of deaths 0·25, and of constantly sick, 0·21, there being little variation in the figures from year to year; whereas in India, excluding the forces on active service, the corresponding rates (1893-1902) are 22·5, 5·94, and 3·25 respectively. That is to say that there were over 17 times the number of cases and over 23 times the number of deaths, in proportion to strength in India as compared with the results in the Home country, the total mortality (all causes) being in the proportion of 3·4 (India) to 1 (United Kingdom). That is to say, that if the rates in the United Kingdom had prevailed in India, which is doubtless an impossible standard, there would, roughly, have been only about 900 cases of Enteric Fever instead of the 15,500, and only 175 deaths instead of the 4,100, which actually occurred during the ten years in question. As will be seen subsequently, the contrast is far more striking when the results in certain localities in India are examined in detail. It may be noted that the situation is very similar, though still less satisfactory, with regard to the French army; the ratios of admissions and deaths from Enteric Fever among the troops serving in the homeland during the period 1888-1902, averaged annually 7·2 and 1·12 *per mille*, whereas, among their European comrades in Algiers—Tunis, the figures rose to 25·0 and 4·2, respectively. These are typical examples of what occurs among similar bodies of men under changed conditions in peace, and when we turn to the records of recent operations of war the testimony is equally impressive. In the short period of the Franco-German campaign (1870-71) no less than 73,396 cases of Enteric Fever were recorded in the German army alone, equivalent to 93 per 1,000 of the average strength engaged. Next, about one-fifth of the men mobilised in the National Camps on their native soil in the United States in 1898 in connexion with the Spanish war, developed Enteric Fever. Among 107,973 officers and men in 92 regiments, the number of cases was 20,738, and of deaths 1,580, equal to rates of 192·6 and 14·6 per 1,000 of strength, respectively. And, again, during the late campaign in South Africa, during the two years, October 1899—September 1901, there were 31,118 cases and 6,172 deaths from this cause alone, and there is reason to believe that many cases were unrecorded. It may be added that the extent of the sickness from Dysentery was almost equally great, although the loss by death was much smaller, but still formidable, *viz.*, 973 fatalities. Turning to the campaigns conducted on and beyond the Indian Frontier since, and including, the war in Afghanistan (1879-80), it appears that 353 deaths have been ascribed to Enteric Fever, but to this figure must be added a large proportion of a total of 210 deaths from Simple Continued and Remittent Fevers, and on this view, the number of cases of true Enteric would probably amount to, approximately, 2,000; beyond this, no less than 283 deaths were recorded under the same circumstances as due to Dysentery and Diarrhœa.

The full significance of these facts will be discussed later; here it is merely desired to present in brief outline some account of the loss incurred by forms of disease which, it is contended, are preventible. We have scarcely emerged from the dominion of the idea that a large class of diseases, the so-called tropical diseases, are essentially different from those encountered in the temperate regions, but a glance at the old Bills of Mortality for London in the 17th and 18th centuries should dissipate the error, which has undoubtedly served to confuse the practical issues.

A more concrete and definite idea of the actual cost of this sickness and mortality may be obtained from the following considerations. During the eight years ending 1902, the total number of cases of Enteric Fever among the rank and file of the European troops in India, amounted to 12,527, the deaths to 3,326, and the number invalided to 367; the average number of men constantly sick from this one cause varied in different years from 117 to 320, and the total loss in days of service thus incurred was 627,866, or, on an average, 78,483 days *per annum*; each case, on the average, keeps a man from ordinary duty for fully 50 days, and in the majority of instances a soldier who has recovered from the disease is unfit for the stress of active service for a period extending from 3 to 6 months. The mortality is of course a very grave addition to the account, the 3,326 fatalities, equal to half a regiment *annually*, amount to no less than 40 *per cent.* of the total loss by death from all causes. It must be remembered that the above facts are taken from the official returns and that they probably fall short of the actual truth; moreover, it is not, as a rule, the "weedy" recruit who falls a victim to this disease, the heaviest incidence is on the trained and promising soldier of between 20 and 24 years of age. In the Report of the Commission appointed by the Secretary for War in 1900, to enquire into the causation of Dysentery and its relationship to Enteric Fever in South Africa, an attempt is made to estimate the monetary cost of the loss by the latter disease, on the basis of the "cheapest trained soldier available" reckoning his value at £40. Such a one who dies and has to be replaced is calculated to cost £87; one who is attacked and rejoins his regiment after 4 months involves a loss of £57; one who is attacked and is invalided Home and has to be replaced by a fit substitute costs the State no less than £108. If we could accept these rates as approximately applicable to India, the distance of which from England is even greater, we may calculate the annual average loss on account of Enteric Fever alone under peace conditions in recent years at something like £107,000, or Rs. 16,05,000. But it is to be noted that the above rates were calculated on the assumption that the "cheapest trained infantry soldier costs £40 by the time he arrives at his destination in South Africa." Now the British private has been estimated by the best authority to cost the Government of India as nearly as possible £100, *i.e.*, for the initial and annually recurring expenditure involved in his maintenance, and as nearly half the number of deaths from Enteric Fever occur after the completion of one year's service in this country, we may fairly take the average monetary loss at £100 for each man. On this basis the total loss incurred annually in India may be estimated at something like £230,000. This calculation has reference to recorded cases only, and as we shall see, there is good reason to believe that an indefinite amount of the sickness due to this cause is included under other heads. The cost of special preventive measures has also to be added to the above sum, which would be further greatly enhanced if other "filth" diseases and their sequelæ were taken into account; these have a similar origin and are propagated and spread in identical ways. It should also be noted that Farr calculated the value of an agricultural labourer, age 20, at £234, and one at the age of 25, at £246, by a careful estimate of the cost, at these ages, "of future maintenance and then of future earnings." ("*Vital Statistics*," page 313.) There is, thus, a large addition to be made, in the loss to the State, beyond that incurred by the Government of India. In addition to this, during the same period (1895-1902) there were altogether 479 cases and 99 deaths among the officers with the British troops, and 40 deaths among British officers serving with the native army; the number of cases among the latter is not available, but it may be reasonably estimated that in the two cadres together there were about 700 cases of the disease, with certainly 139 deaths, *i.e.*, an average of 85 cases, and the total loss of over 17 most valuable lives every year. Finally, apart from this loss in efficiency and *personnel*, which falls chiefly upon the early age periods, there is the indubitable effect of impaired health on the morbidity and mortality from other diseases at the later ages.

Before proceeding to attack the problem in detail, it is essential to advert to certain factors of a general nature that have operated on the health conditions of the British army in India during the last 50 years; these will be merely summarized in the first instance and their bearing on the problem will be indicated in due course.

I. *Changes in the character of the personnel.*—In this connexion reference will be made chiefly to the age constitution of the forces, but beyond this, it may merely be noted that the class from which the army has drawn its recruits has probably varied in considerable, but inestimable, measure, on account of economic causes affecting the labour market in Great Britain; the growth of urban communities, the rise of industrialism and the general improvement in the sanitary and economic lot of the mass of the people. The Mutiny found us with an army composed of long-service "veterans," but one of its immediate results was to flood the service in India with young men with no experience of a tropical environment. In 1858 the proportion of men serving in India of 25 years of age and under was even larger (*viz.*, 59 *per cent.*) than it has ever been subsequently under the Short Service system; up to 1856 the proportion at this age was only 26 *per cent.* The following figures will demonstrate clearly the great change that took place as regards both age and service:

Proportions per cent. at different ages.

	20 years and under.	21—26 years.	27—36 years		36 + –
Army of 1858.	16·28	43·58	33·55		6·6
		20—25	25—30	30—35	35 + –
Army of 1847-56.	2·2	24·0	33·0	21·5	19·3

In the army before the Mutiny no less than 32 *per cent.* of the whole had 5 to 10 years' service in India, and 25·4 *per cent.* had over 10 years' service.

Next, after the Mutiny and up to the early "seventies" when the Short Service system began to affect India, we find a gradual but distinct decline in the proportion of young and newly-arrived men, the 59 *per cent.* in 1858 falling to 38 *per cent.* during 1871-75. It is stated in the Report of the Royal Commission of 1863, that 4,000 men as drafts had been found sufficient to provide for the yearly loss in deaths and invaliding for a force of 40,000 prior to the Mutiny. But as one result of this catastrophe, we had, first, an *increase in the force* maintained in the country to between 60,000 and 70,000 men and, then, with the full operation of the Short Service system a few years after 1875, the annual tributes of drafts or reliefs to supply the loss by death, invaliding and term-expired men, rose to an average of nearly 14,000. Save for a slight reduction to about 10,000 in each of the two years, 1881-83, and for the suspension of the supply of men in 1899-1901 owing to the exigencies of the Boer War, this influx has been maintained annually for a quarter of a century: year by year a number almost equal to one-fourth of the total strength exposed has been landed in India, with the results of a constantly increasing tendency to lower the age-constitution of the *personnel*, and also of a constantly recurring renewal of that *personnel*, which is composed very largely of men at the most susceptible ages, and who are in all cases aliens to the environment. The following figures will show the position more clearly:

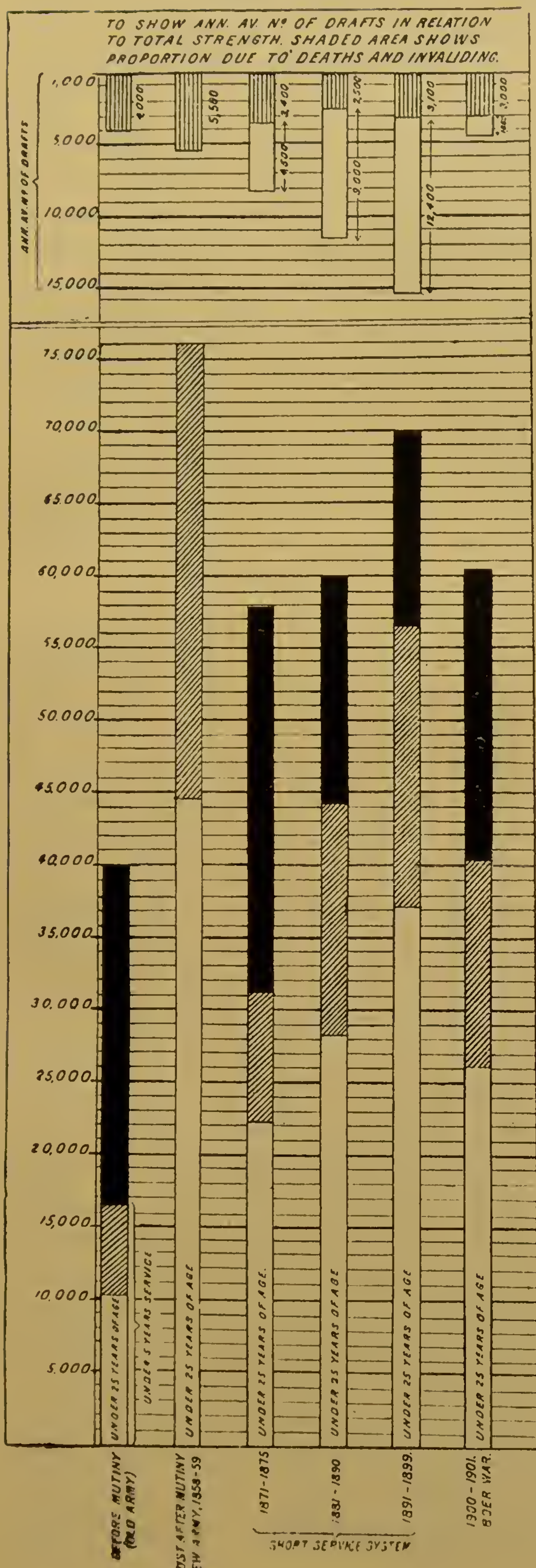
ARMY OF INDIA.

Proportions per cent.

	At each Age period.					*At each period of Service.*						
	Under 20,	20-25,	25-30	30-35	35+	Under 1 yr.	yrs. 1-2	yrs. 2-3	yrs. 3-4	yrs. 4-5	yrs. 5-10	yrs. 10+
1877	2	31	35	16	16	13	11	11	12	8	34	10
	33%										44%	
1897-98	3	52	35	7	3	19	18	18	16	13	14	3
	55%										17%	

The proportion *per cent.* of men under 25 years of age thus rose from 33 to 55, and of those having less than 2 years'

CHART No. 1.



service in India from 24 to 37, and of those having less than 5 years' service from 56 to 83.

The accompanying diagram (I) affords a graphic conspectus of the *personnel* (rank and file) of the European army in India during six representative periods in the last century; *viz.*, of the old long-service before the Mutiny, of the new army that occupied the country just after the Mutiny, of the remnants of the force under the long-service system (1871-75), and of the modern short-service army in three periods ending with that of the Boer war. The entire columns, ascending from below, represent the total average strength exposed in each period, and they are divided up to show the average numbers under 25 years of age (blank space at base) and under 5 years' Indian service (blank and cross-shaded areas *combined*). The columns descending from above stand for the actual numbers drafted into the country annually to maintain the force, the shaded portion showing the numbers required each year to replace the loss by deaths and invaliding. The demonstration of the radical changes in the *personnel* at risk and of the conditions of service could scarcely be more clear and convincing. Summarizing the main facts for the last three decades of the century we see that in 1870-78, the number of drafts and reliefs required annually to maintain the strength was about 8,000, of which a little more than half were to replace the losses by death and invaliding. Leaving the period of the Afghan war out of account, and taking the next period (1881-88) the yearly tribute of drafts rises to about 12,000, the average losses by death and invaliding falling to 3,700. In 1890-99 the new men were imported at the rate of 15,000 a year of which only some 3,300 were for the replacement of those who died or who were invalided. So that during the 30 years, the proportion of new arrivals to the total strength exposed rose from about one-seventh to between one-fourth and one-fifth. Lastly, 40 years ago (1864-69) just half the men in the first year of their Indian service were over 25 years of age, *i.e.*, they arrived in the country at a much maturer age.

This radical change in the *personnel*, younger men and these more frequently renewed, has involved a marked change in the character and amount of the sickness, of the death and of the invaliding rates. Other factors were, as will be seen, in operation, but the net result is a diminution in total mortality and of the morbidity to which older men are liable, with an increase of that to which the younger men and new arrivals are most subject. We have, in fact, not only changed fundamentally the age-constitution of the army, but by the more frequent changes in the body as a whole, the results have been accentuated by the operation of a distinct factor, *viz.*, the reaction of the human material at risk to a totally strange environment, with the consequent defective physiological adjustment, an influence to which attention will be directed in the discussion of the etiology (Chapter III.). One main result of these factors in combination has been to alter the curve of the death-rate which formerly exhibited a more or less steady rise with each age and service period, to give it the characteristic "hump" which now marks the early periods owing to the heavy mortality incident thereon, and which is followed by a rapid decline. In a subsequent section of this chapter, the changes in the constituent elements of the morbidity and mortality rates will be indicated in detail so far as they affect the course and rise of Enteric Fever in the vital statistics. Here it need only be added that the conditions described obviously provide a far larger number of individuals susceptible to those infectious diseases which have a specially heavy incidence on young adults, and further, that with the multiplication of individuals attacked the number of centres of infection is increased with proportionate danger to the community. Lastly, with regard to the change in *personnel*, some regard must be paid to the fact of the great decrease in the prevalence of Enteric Fever among the population from which recruits are drawn in the United Kingdom. Fewer men are now protected by a previous attack of the disease, fewer susceptible subjects are eliminated, and the individual and racial resistance to infection is thereby reduced.

The facts elicited by the recent Committee appointed to investigate the question of the physical deterioration of the people of England, appear to show that the army has, in recent years, ceased to attract the class of men who formerly enlisted. There has been a greater drain on the residual and more helpless stratum of the population, and though selection has secured the best available, the physique of the "weedy recruit" has long been a bye-word of reproach. With this, there has been a gradual but constant increase in the strain involved in service in the ranks. The rising economic prosperity of the nation has involved acuter competition which has tended to throw the unfit out of work, and when trade conditions are brisk many of the poorest specimens of our manhood are secured for the army ; and these are largely the failures in the battle of life, who have lived a hand-to-mouth existence on stimulants and inferior and inadequate diet and who have a constitutional incapacity for order and forethought—a leisured and incapable class at the bottom of society.

II. *Movements of the Army ; Traffic and Intercourse.*—With the growth of the Empire and increased Colonial responsibility there has been increased traffic along the great lines of communication, and more rapid transit from home to the tropics and to sub-tropical garrisons, and between the latter. Without laying undue stress upon the connexion, we shall see that Enteric Fever began to assume a prominent place in the returns with the establishment of the far more rapid transit of troops to India by the Overland passage. The significance of the fact has a three-fold bearing on the problem ; *viz.*, on the question of importation of the infection, on the effect upon the susceptible material exposed thereto of a rapidly changed environment and the consequent physiological maladjustment to the new conditions and, lastly, on the results of previous experience of the disease and of more or less adjustment to sub-tropical environments elsewhere ; evidence will be adduced on all these points. There is, it may be said, however, not only the greater risk of infection of transport ships, of ports, railway stations and rest camps *en route* (and the homeward-bound must also be taken into account here, altogether something like 28,000 men passing in and out every year), but owing to the fact that, on disembarkation, a large body of susceptible individuals is distributed to many different cantonments, the chances of dissemination of infection are increased. Any large body of men at the soldier's age is almost certain to include a few cases of the disease in a latent or more advanced stage, if only on the basis of the rate of attack prevailing in England among the civil population ; these men are aggregated closely under the conditions of life on a transport, which provide every facility for the dissemination of the specific virus among them though cases may not appear till later. We should also expect to find some relation between the prevalence of Enteric Fever in India and the places from which regiments arrive, *e.g.*, from England or from the Mediterranean or African stations (Egypt and the Cape). In the former case, the men should be more susceptible to the disease, having little experience of it, and being new to the environment ; in the latter cases there is greater risk of importation of the infection. Within the limits of the Indian continent, there has been an increase of traffic between stations along the main strategic lines,* more frequent and rapid inter-station transfers, more frequent "route-marching" and aggregation for field manœuvres involving camp-life ; there has been a very large increase in the number of men sent annually to the Hill stations, and, lastly, there has been a tendency to concentration of the forces towards the continental North and North-West area. All this has had an undoubted influence on the propagation of Enteric Fever, while some at least of these movements have served to diminish other sources of loss.

III. *The life-habits of the Soldier.*—Certain points concerning what may be called the domestic economy of the modern soldier will be touched upon in a subsequent chapter. Here two points only will be noted ; first, the great decrease in the amount of drunkenness which is noticeable during

* In 1886, there were about 6,000 miles of railway open for traffic in India; in 1906 there will be about 29,000 miles in use

the last 30 years. In 1871-75, on an average, 19,812 men out of an annual strength of 58,540 were convicted yearly of this misdemeanour, *i.e.*, 34 *per cent. per annum*; during the last three years the rate had fallen to a little over 12 *per cent.* During the same period the admission rate for Delirium Tremens has fallen from 3·6 per mille to 0·109, *i.e.*, only 1 case to 33 formerly. This great change has doubtless affected chiefly the older men, and is partly the result of a younger army, and we see the results in a great reduction in the rates from Hepatitis, Apoplexy and Heart diseases. Men must drink in this climate, and there has probably been a great reduction in the amounts of spirits and beer consumed in favour of water, plain or sophisticated in one or other way. During the last ten years the average number of members of the Army Temperance Association has been nearly 24,000, or over one to every three men in the army in India. At the same time there has been a very marked rise in the sickness from Venereal diseases, the rates having steadily risen in 1896 to over twice the figure for 1870. If the Enteric infection be ordinarily derived from native sources, bazars, brothels, etc., we should expect to see a concurrent rise in the rates from the two diseases, and this question will be discussed in due course.

IV. *The relative increase of Invaliding.*—Although the actual rates in proportion to strength have fallen to a slight extent, the diminution has not by any means been proportionate to the decrease of serious sickness. The men are now more carefully tended, and invaliding is now resorted to at an earlier stage and for slighter degrees of impaired health; the mesh of the net is smaller and thus fatal casualties are often obviated to the advantage of the death-rate. In 1871-75 there were 12,017 men invalided, an average rate *per annum* of 40·7 *per mille*; of the total number 26 *per cent.* were discharged as unfit for service, 74 *per cent.* for rest and change. In 1901-03. 6,711 men were invalided (35 *per mille* against 40 in the previous period), but no less than 38 *per cent.* of the total were finally discharged, leaving 62 *per cent.* to return to duty. With the diminution of serious "degenerative" diseases there has therefore been a rise in the invaliding rate for *discharge*, and thus many men escape death in India who would formerly have gone to swell the death-rate; but this change chiefly affects the higher age and longer service periods and has its relation to the Enteric death-rate simply in altering the relative proportion of this to the total death-rate.

V. *Improved Sanitary Conditions and Medical Service.*—A perusal of the Report of the Royal Commission of 1863 will demonstrate clearly how far we have advanced in nearly every direction of sanitary effort during the last 40 years, and notably in the provision of purer water-supplies, better barracks and accommodation generally, more adequate drainage of sites, more suitably adapted clothing, in arrangements for personal cleanliness, in improved dietary and in the transfer of larger numbers of men to the Hills in the hot weather and monsoon periods. In those days, the latrines were simple cesspits, and problems of disposal of sewage and sullage did not enter into calculation, or were neglected generally until about 1870. The "dry earth" system with trenching, more or less deep, was then generally introduced and has subsequently held the field, with modifications chiefly in the direction of the deposit of "night soil," etc., in shallow trenches with a light covering of earth and with subsequent cultivation. The latrines have varied little in construction during the last quarter of a century, and, at this point, it is only necessary to emphasize this fact together with the change in the methods of *disposal*, while the sources of water-supply, though far better chosen and conserved, have remained practically the same as formerly. This most important subject will receive due attention in the sequel, but we shall see how marked a reduction has taken place in the amount of water-borne disease (excluding Enteric) so that it is evident that there has been some etiological factor in operation which determines this remarkable contrast. If, indeed, water (plain and "mineral") and food consumed in the native bazars be really the chief sources of Enteric infection, it is difficult to understand the extraordinary reduction that marks the returns as regards cholera, dysentery and diarrhœa, for these latter diseases are constantly rife among the natives, and we may assume that water and food are the chief vehicles of these infections. With the improvement of cantonment water-supplies (even if it be allowed that much is left to be desired in this respect), the Enteric Fever rates have risen enormously, and it does not suffice to refer the result to the altered age and service constitution of the army, as these other "bowel complaints," which have diminished almost as markedly, have always shown a special incidence on the younger and newly-arrived men.

Here, indeed, we approach the crucial element in the problem, and the question we have set ourselves to answer:

Have we grasped the true etiological significance of Enteric Fever as it presents itself to us in India? Have we applied our knowledge to the extirpation of the root of the evil? It will be our endeavour to supply answers to these questions, to formulate a truer and completer conception of the etiology of the disease and to indicate a rational basis for preventive measures. We have, however, yet to add to the considerations coming under this section, that the general improvement in sanitary conditions has, to a large extent, rendered the army far less subject to sudden and exhausting epidemics, which formerly marked the death-rates with their characteristic fluctuations. Doubtless, many men in former times fell victims to cholera, dysentery and so-called "ardent" or malignant fevers, and who perforce escaped the attack of Enteric Fever, which is now left largely in possession of the field. As epidemics of the class of specific filth infections become less frequent or disappear, the same and other diseases of an allied nature diminish under the influence of the same preventive measures with the result that the total actual gain is far greater in the non-epidemic periods than is achieved by the abolition of the epidemics *per se*. Significant fluctuations in the death-rates are still far too evident as an indication that we have not yet obtained control of the conditions that affect the health of the troops, and when we analyse the causes of mortality the fact is brought home that Enteric Fever still defies us, and that of this we may well declare, "*voilà l' ennemi!*"

A brief comparative statement is appended which shows the extent and chief causes of the mortality in two periods, *viz.*, 1860-69 and 1890-97, in the area included in the old Bengal Presidency, wherein two-thirds of the European army is ordinarily cantoned. The former period may stand for the end of what may be called the pre-sanitary era, and the latter has been curtailed to some extent, to include only 8 years' results against 10, in order to represent fairly ordinary conditions and to exclude the effects on the *personnel* of the South Africa war. The figures need no comment beyond that afforded by the diagram on page 15, as some of the chief features in the contrast will be discussed in the following chapter. Excluding cholera from both accounts as little liable to diagnostic error, we see that bowel complaints and fevers together (any or all which may conceal true Enteric, which was not then recorded), caused mortality at the rate of 7·80 *per mille* in the earlier period, or, 26 *per cent.* of the total mortality, but that the same diseases including Enteric fever, accounted for a death-rate of 9·02 in 1890-97, which is about 51 *per cent.* of the total.

TABLE I.

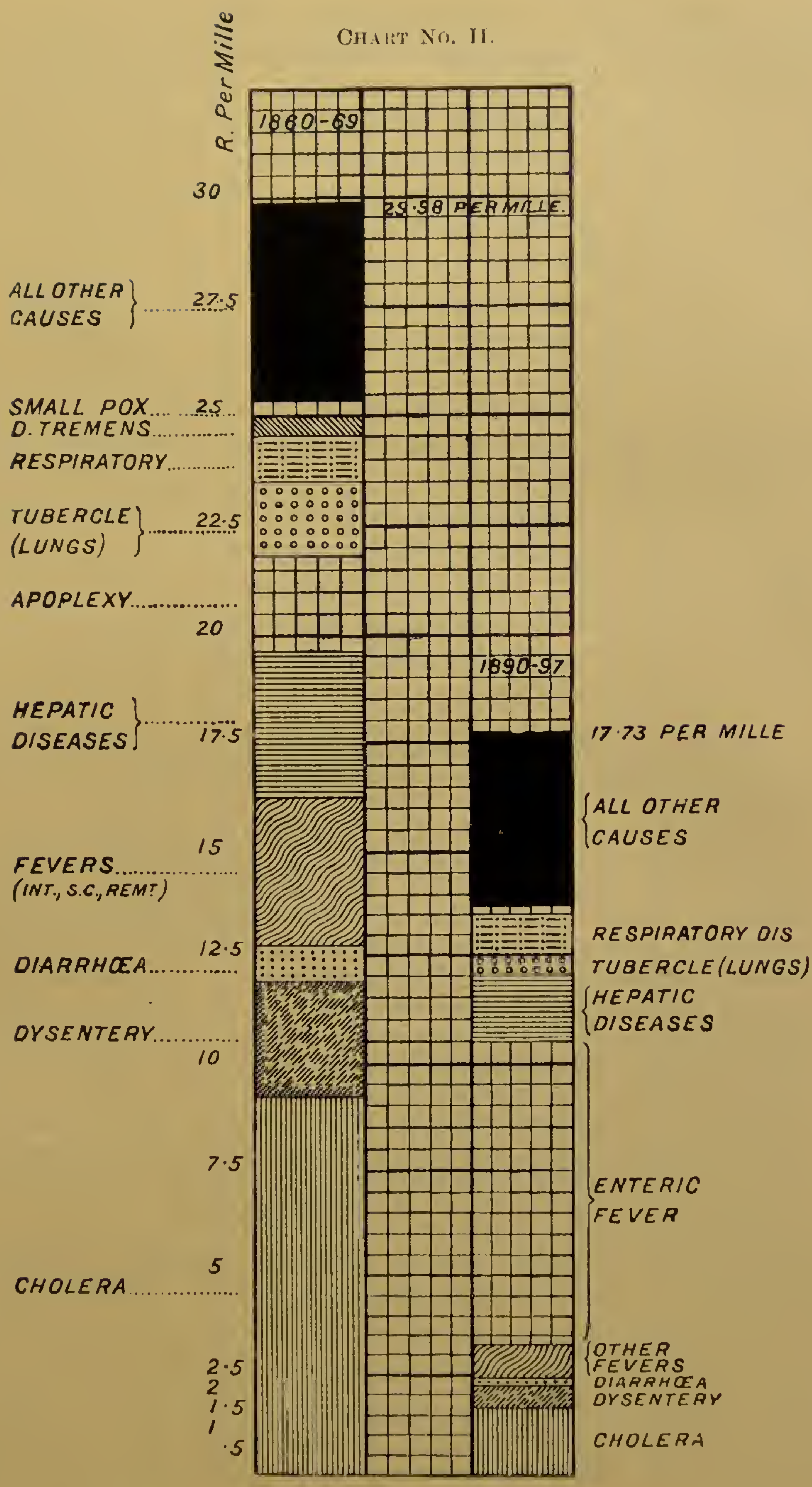
Sickness and Mortality in the Bengal Presidency.

Mean-rates per 1,000 *in* 1860-69 *and* 1890-97.

	Mean-rates per 1,000.			
	1860-69.		1890-97.	
	Strength 390,678.		Strength 332,537.	
	Ad.	D.	Ad.	D.
Cholera ...	14·7	9·24	2·2	1·60
Dysentery ...	48·9	2·72	28·1	·83
Diarrhœa ...	109·4	·75	29·8	·05
Intermittent Fever ...	439·0	·66	389·6	·21
Simple Continued Fever	194·0	2·92	35·8	·00
Remittent Fever			13·1	·60
ENTERIC FEVER ...	......	......	**28·3**	**7·33**
Influenza ...	......	......	9·8	·04
Hepatic Abscess	59·2	3·31	1·8	1·23
Hepatitis			16·2	·04
Apoplexy ...	4·3	2·19	·03	·03
Tubercle of the Lungs ...	8·2	1·73	3·1	·58
Pneumonia	74·7	·99	4·7	·84
Other Respiratory diseases			32·0	·19
Small-Pox ...	2·2	·34	·5	·05
Delirium Tremens ...	4·7	·48	·2	·02
Venereal Diseases ...	265·5	......	474·5	·09
All Other Causes ...	530·2	4·65	428·1	4·01
ALL CAUSES ...	1,754·9	29·98	1,497·8	17·73

As regards the improvement in the medical service of the troops, which is undoubted, it is obvious that this should be a potent factor in the real reduction of an infectious disease by virtue of the earlier and exacter diagnosis and the better and completer treatment it should afford. As regards diagnosis more will be said in subsequent chaps. II. and III., but, so far, it may be noted that, hitherto, its most striking and obvious result has been to lay bare the facts of the extent of the disease, and we shall have to distinguish between an

CHART No. II.



Mortality in the Bengal Presidency, 1860-69 and 1890-97.

apparent, and, what it is believed the evidence will prove to be, a true increase in its prevalence. Finally, it may perhaps be said that the necessary administrative changes in the *personnel* of the staffs of the army hospitals, which must always be more frequent than in civil institutions, constitute a factor which is not favourable to the control of the health conditions of the troops.

Having cleared the ground of these preliminary considerations, the subject will be discussed in the following order: a brief account of the course and extent of the disease as exhibited in the statistics will be followed by a discussion of the essential points of the etiology. We shall then give a sketch of the present position in its broad epidemiological features, to be followed by a section on the special conditions affecting the prevalence of the disease in the army in peace and war. And, finally, the conclusions will be summarized, with the preventive measures thereby indicated.

Before proceeding with our task, we may recall the eloquent words of a great teacher of the science of war, in reference to the conditions under which the British soldier is called upon to serve his country.

> "The laureate of the Army has nowhere struck a truer note than in the line which crystallizes the distinctive character of the British soldier.
>
> 'I have heard the reveille from Birr to Bareilly.'
>
> How far do its echoes reach, gathering in one sheaf the memories of a lifetime? And not the memories only, but the experiences. Experiences of many men and many lands; of divers races and of the extremes of climate; of long voyages over lonely oceans; of storm and pestilence; of service in island fortresses; of outposts in brown deserts, far beyond the verge of civilization; of times and places where men hold their lives as lightly as their gloves; of vast cities, teeming with an alien population, over-awed by a few companies of red-coats; of great armies of dark faces loyally obedient to a handful of white officers; of warlike expeditions hastily organised, where one man has to do the work of ten; of long campaigns in waterless solitudes under a brazen sun; of enemies who give no quarter, and of comrades who know no fear." (Lectures on "The Science of War," by Col. G. F. H. Henderson, C.B.)

We, too, shall march from Birr to Bareilly—but the call of the reveille is lost in the requiem of the muffled drums.

CHAPTER II.

Course and Rise of Enteric Fever in the European Army in India.

The scope of this Essay does not permit of an elaborate review of the history of the discovery of Enteric Fever in India as a distinct specific entity among the confused jungle of tropical fevers, nor of the long conflict of testimony and opinion which ensued and of which the echoes have not yet entirely subsided into silence. It is not that the subject has not an interest and importance of its own, but the controversy was not confined to India and scarcely any chapter of medical history has been more fully recorded. Its practical bearing on the problem to-day lies in the fact, not that any doubt can persist of the true nature and prevalence of the disease, but rather in the difficulties which attend its recognition in its lighter and less typical manifestations in places where other continued fevers prevail, and especially in tropical and sub-tropical regions. Although we can recognize the disease in the descriptions of certain forms of fever given in the writings of the older Indian physicians in the early part of last century, it is to Scriven that the credit must be assigned of having definitely identified the first cases among Europeans, and this was in 1854 ; but Stewart had given a perfect clinical description of the disease among men of the 9th Lancers as early as 1844.

Two years later (1856) Ewart reported, and preserved pathological specimens of, the disease among native prisoners ; from this time the annual reports of the regimental surgeons contain references to more or less isolated cases, and in the Army Medical Report for 1861, there is an account of an outbreak in an European regiment at Deesa, 1859. It is significant that at this time the army was largely augmented by an influx of young men, the proportion of whom to the total touched a point never subsequently attained even under the short service system. From 1859 to 1864 no new regiments had been brought into the country, but with the commencement of regular reinforcements from home in the latter year, the study of the disease received a fresh impetus; observations accumulated from various places that the case mortality of certain anomalous continued fevers was excessively high and a perusal of some of the old regimental records show that the seasonal incidence of these cases was very similar to that which is now recognized as characteristic of Enteric Fever. The true significance of the facts was now recognized by many medical officers, and some no longer hesitated to affirm their convictions in the official returns, for in those of the Bengal Presidency for the period 1862-1870 we find a record of 302 cases with 154 deaths, a case mortality which conveys an obvious implication. From 1871 the disease finds a place in the Reports from all three Presidencies, and we shall return later to a brief summary of the results which exhibit the statistical course of the disease up to the present time.

If, in the light of more recent experience, this statement appears to convey some reproach on the clinical acumen of Indian observers, there are many valid grounds for a plea of absolution. The fact must be remembered that the disease had only recently been differentiated from Typhus fever in Europe, and here in India, the circumstances were altogether more difficult owing to the prevalence of other fevers of a "continued" and "remittent" type, of bowel complaints and *of both in combination.* The vaguest notions of the true nature of Malaria prevailed, and even to-day, in this respect we have not yet emerged from twilight into the full light of day. One of the salient features of the history of Indian fevers is the marked diminution of the old type of "ardent" or malignant and "bilious remittent" fever, so prevalent and fatal in the early part of last century; the writings of the older observers leave the impression that their experience was very different from ours in this respect, and probably some of the considerations advanced in the previous chapter have a direct bearing on this phenomenon. The whole *facies* of the disease so described is alien to that of Enteric Fever; at the same time it is only necessary to consult a standard text-book on the subject of the latter to appreciate how greatly the type of the disease may vary, and how recent is our knowledge of its protean character. The pyrexia of Enteric frequently assumes a distinctly remittent type and there are other aberrations familiar to all observers, the clinical picture being determined largely by the predominance of the implication of either the abdominal or the thoracic organs or of the nervous system, and by the accompanying septicæmia; while the personal factor, and notably that of age and temperament, influences the reaction of the tissues to the virus. We are only now beginning to recognize the occurrence of allied but distinct forms of the disease in the so-called "paratyphoid" infections, which in many cases present a pathological picture intermediate between that of Dysentery and that of true Enteric. On the other hand, the reaction from the primitive view expressed by Moorhead that "typhoid fever is unknown" in India has shown a tendency to express itself in the conclusion that all inflammatory and ulcerative lesions of the ileum found *post-mortem* after continued or remittent fever are diagnostic of Enteric Fever, and by some, indeed, a fatal result alone in these cases has been similarly interpreted. But this scarcely needs serious refutation; we are still unable to read the riddle of a large class of Indian fevers, but that there are forms which may more or less simulate Enteric, but which are yet etiologically quite distinct, is certainly true. To go no farther than undoubted Malarial infection in its graver forms, there is abundant and irrefragible evidence of this in regard to both the clinical and pathological appearances. In regard to the latter we know that stasis produced by the presence of the hæmamœba in the intestinal capillaries may so impair the vitality of the tissues as to lead to necrosis and invasion by pyogenic organisms from the bowel, and so to fatal enteritis with septicæmia. The mucous membrane of the intestine may be found in an advanced stage of superficial necrosis or of ulceration, with cellular infiltration of the deeper layers, which are intensely congested and occupied by hæmorrhages. The observations of Vandyke Carter on a form of "Peyerian lesion" (ulceration) found in subjects of Remittent fever, but which was distinctly not Enteric in many essential characteristics, are of importance in this connexion. The subject is apart from the direct line of our present enquiry, but as bearing on the argument it can scarcely be passed over without a bare allusion; for specific details, reference should be made to the works of Murray, Daniels, Mannaberg, Vandyke Carter and Martin, quoted in the bibliography. It is scarcely necessary to allude to the well-established occurrence of ulceration in cases of Syphilis, Tubercle, Dysentery, simple fæcal poisoning and in the form of tropical fever now associated with the Leishman-Donovan bodies, and in all these cases the pyrexia may assume a more or less Enteric type especially in subjects of Malarial infection. Lastly, there is the concurrence of testimony of observers in the tropical colonies, in Mediterranean stations and in Africa, to the fact that outbreaks of Enteric Fever are accompanied and often preceded by an excessive prevalence of continued fevers and of bowel complaints, and when we come to discuss the seasonal incidence of Enteric, we shall observe a similar phenomenon as to which the evidence is distinctly against a common origin and etiology for these various morbid manifestations, though certain factors may be in common operation. At this stage we are merely concerned to indicate some of the peculiar difficulties that beset the recognition of the disease and which may throw some light on the course of opinion and of the statistical record. Much of the obscurity through which we have attained to clearer notions is due to ignorance of the biology of the specific causative agent, of the nature of the infection, its sources and means of propagation; and, on the other hand, to the fact that there are other fevers and bowel complaints etiologically distinct and yet related generically, and occurring under similar circumstances.

The way is now clearer for a brief summary of the facts which exhibit the course of the disease since its admission to the Returns in 1871, and it will be necessary to associate with the record of Enteric, the figures for Remittent and Continued fevers for reasons which will be obvious, both from what has been said and to illustrate the subsequent discussion. In this connexion Chart No. III. should be studied. As the true nature of the disease was only very partially recognized during the earlier years of the record, the figures for 1871-79 are aggregated into combined ratios, but from 1880 onward the yearly record is complete together with the quinquennial averages for comparison.

Table No. II. tells its own story and scarcely needs comment. First, as regards India as a whole, we see in Enteric Fever a steady and consistent rise in the rates up to the end of the penultimate quinquennium (1895-1899) when the acme of prevalence was recorded, and for the last five years the rates have fallen to a certain degree, but are still higher than at any period up to 1888. The same remarks apply to the total fever rates, *i.e.*, for Enteric and non-Enteric fevers combined. This last period of decline embraces that of the Boer War, during which the supply of reliefs and drafts was almost entirely suspended and the age and service constitution of the army was

TABLE No. II.

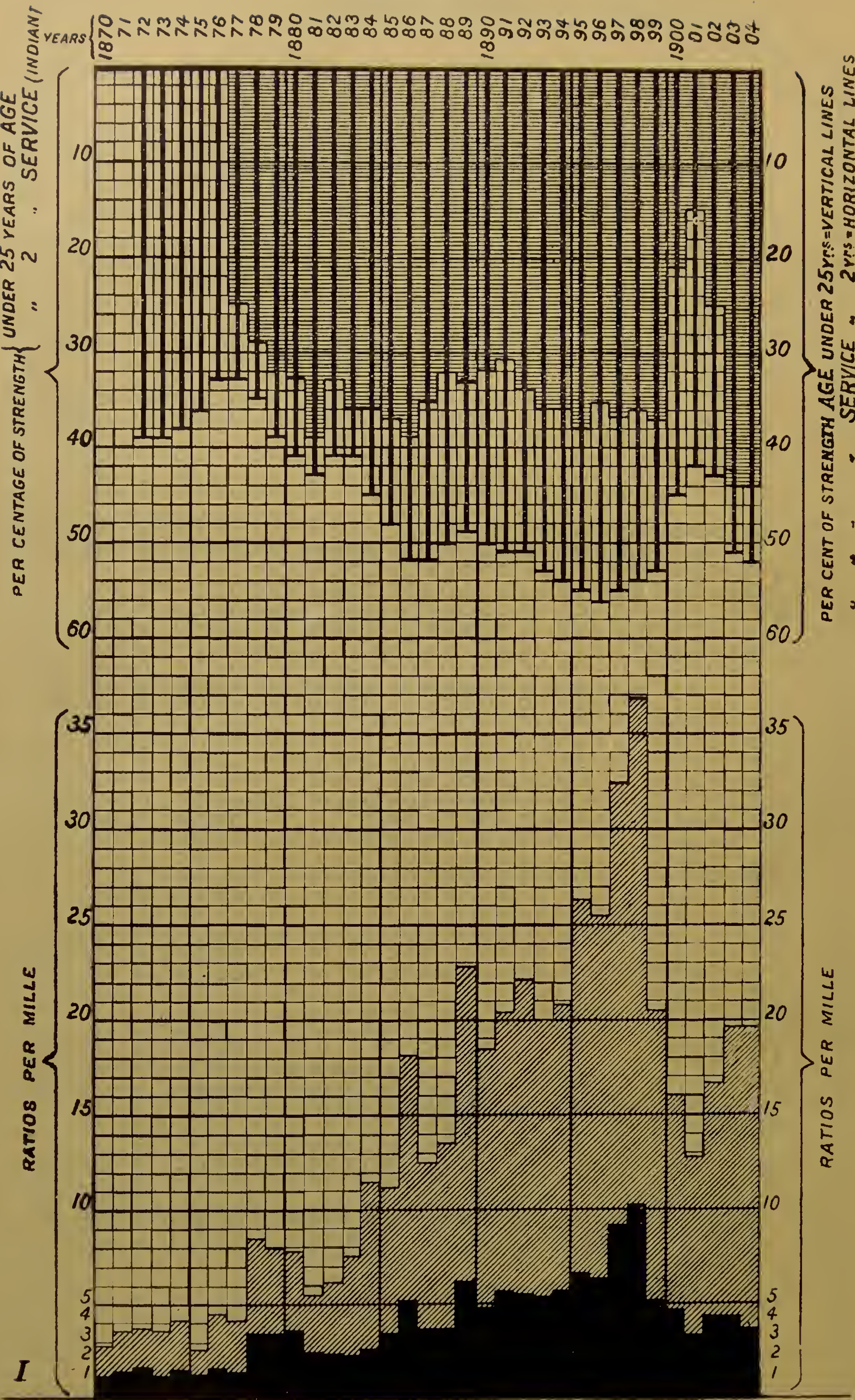
Enteric and other Continued Fevers in the different Presidencies (or Commands since 1895) for the last 35 years, 1870-1904.

	Years.	Bengal. Enteric Fever. A. R.	Bengal. Enteric Fever. D. R.	Bengal. Remittent and S. C. Fevers. A. R.	Bengal. Remittent and S. C. Fevers. D. R.	Punjab.* Enteric Fever. A. R.	Punjab.* Enteric Fever. D. R.	Punjab.* Remittent and S. C. Fevers. A. R.	Punjab.* Remittent and S. C. Fevers. D. R.	Madras. Enteric Fever. A. R.	Madras. Enteric Fever. D. R.	Madras. Remittent and S. C. Fevers. A. R.	Madras. Remittent and S. C. Fevers. D. R.	Bombay. Enteric Fever. A. R.	Bombay. Enteric Fever. D. R.	Bombay. Remittent and S. C. Fevers. A. R.	Bombay. Remittent and S. C. Fevers. D. R.	All India. Enteric Fever. A. R.	All India. Enteric Fever. D. R.	All India. Remittent and S. C. Fevers. A. R.	All India. Remittent and S. C. Fevers. D. R.	India:—Total Fever mortality.
Presidency Armies.	1870—79	5·3	2·28	181·9	1·57	..	..	..	..	3·9	1·42	126·3	·60	3·1	1·75	131·4	·98	4·6	2·03	162·2	1·28	3·31
	1880	8·8	3·69	133·1	3·06	..	..	..	..	2·6	1·36	71·9	·29	9·5	5·76	122·3	2·72	7·9	3·63	120·7	2·58	6·16
	81	6·3	2·62	100·9	·69	..	..	..	..	·9	·58	40·6	·20	4·2	2·83	86·2	·91	5·6	2·64	87·1	·64	3·28
	82	7·3	2·90	63·2	·74	..	..	..	..	4·0	2·09	25·8	·27	5·1	1·90	46·1	·54	6·2	2·55	52·6	·61	3·16
	83	8·1	2·52	61·7	·41	..	..	..	..	8·6	2·86	29·8	·29	5·7	1·55	30·9	·55	7·7	2·40	49·6	·41	2·81
	84	12·6	3·31	59·7	·36	..	..	..	..	11·4	1·67	36·2		9·1	2·05	84·6	2·05	11·7	2·74	59·9	·62	3·36
	1880—84	8·6	3·03	85·3	1·11	..	..	..	..	5·5	1·72	40·6	·21	6·7	2·76	72·7	1·33	7·8	2·80	74·7	·98	3·78
	1885	14·0	4·05	45·5	·54	..	..	..	..	6·4	2·19	31·5	·19	7·3	2·54	68·3	1·49	11·2	3·41	47·5	·66	4·07
	86	21·6	5·70	108·8	·83	..	..	..	..	11·9	3·85	124·8	·89	12·3	4·16	114·4	·27	18·1	5·08	112·7	·74	5·82
	87	13·4	4·09	93·5	·64	..	..	..	..	11·5	2·98	67·9	·51	11·3	3·40	103·8	·72	12·7	3·76	90·6	·63	4·39
	88	16·2	4·15	86·3	·18	..	..	..	..	7·4	2·26	70·1	1·91	11·6	4·04	98·3	·34	13·6	3·75	85·1	·57	4·32
	89	25·8	6·68	70·4	·35	..	..	..	..	16·2	4·48	90·3	1·39	20·3	5·93	72·6	·70	22·9	6·11	74·7	·62	6·73
	1885—89	18·3	4·96	81·6	·49	..	..	..	..	10·8	3·17	77·5	1·05	12·8	4·06	90·9	·70	15·9	4·45	82·5	·64	5·09
	1890	24·1	6·26	75·3	·34	..	..	..	..	9·3	3·65	64·8	1·09	10·2	1·88	61·4	·31	18·5	4·91	70·6	·48	5·39
	91	24·9	6·64	47·2	·39	..	..	..	..	10·8	3·08	78·4	·88	15·7	5·58	64·5	·16	20·4	5·73	56·6	·43	6·16
	92	26·8	6·40	70·1	1·61	..	..	..	..	11·9	3·18	73·4	·46	17·5	5·03	93·1	·32	22·1	5·52	75·0	1·14	6·66
	93	24·9	6·40	32·9	·74	..	..	..	..	11·5	3·35	57·6	·15	12·8	3·70	37·7	·07	20·0	5·29	38·6	·50	5·79
	94	24·1	6·78	28·9	·41	..	..	..	..	10·3	2·91	34·9	·37	20·6	5·22	25·9	·29	20·9	5·75	29·5	·38	6·13
	1890—94	25·0	6·50	50·5	·69	..	..	..	..	10·7	3·24	61·8	·58	15·4	4·28	56·0	·23	20·4	5·44	53·8	·59	6·03
Commands.	1895	30·3	7·59	43·3	·09	39·0	10·29	28·6	·66	12·7	2·61	33·0	·22	16·3	4·48	31·6	·38	26·3	6·72	34·7	·34	7·06
	96	30·2	7·70	47·5	·45	25·9	6·11	45·4	·69	16·8	4·23	57·7		25·5	6·36	24·8	·32	25·5	6·31	43·9	·40	6·71
	97	39·1	10·39	62·3	·10	42·1	11·05	50·4	·70	19·2	4·93	93·7	·49	20·4	6·46	44·2	·54	32·4	9·01	68·3	·61	9·62
	98	41·1	10·47	49·0	·10	48·7	14·74	133·0	·87	11·6	2·27	62·4	·32	35·1	9·92	56·0	·34	36·9	10·17	75·4	·43	10·60
	99	22·8	5·50	37·4	·09	24·9	6·64	47·3	·39	12·1	3·03	45·6	·16	19·4	4·66	37·8	·06	20·6	5·14	41·7	·17	5·31
	1895—99	32·5	8·27	37·7	·17	36·1	9·75	60·6	·66	14·5	3·41	58·0	·24	23·2	6·33	38·6	·33	28·3	7·46	52·6	·39	7·85
	1900	12·8	3·64	50·8	·21	15·5	4·35	23·8	·24	11·7	4·71	33·4	·20	23·5	6·71	36·7	·14	16·0	4·77	37·1	·20	4·97
	01	13·3	2·58	24·4	·21	12·6	4·99	25·4	·12	6·4	1·75	34·3	·10	16·6	3·50	40·7	·39	12·8	3·32	30·7	·22	3·54
	02	17·2	4·00	22·0	·06	18·0	5·05	18·1	·32	8·7	1·71	20·1	·09	20·4	5·69	24·0	·28	16·7	4·29	20·7	·20	4·49
	03	22·6	4·39	27·3	·05	19·8	4·39	25·9	·11	10·3	2·85	19·9	·46	23·1	4·63	16·2	·12	19·6	4·19	22·5	·15	4·34
	04	23·3	4·83	42·6	·14	20·6	42·6	23·3	·05	16·2	2·30	24·8	·23	17·8	3·39	16·7	..	19·6	3·76	27·1	·10	3·86
	1900—04	18·1	3·92	33·8	·13	17·4	4·59	23·3	·16	10·9	2·63	26·0	·23	20·3	4·75	26·6	·18	17·1	4·06	27·4	·17	4·23

Note.—Punjab Command included in Bengal Presidency up to 1894.

A. R.—Admission rates D.-R.—Death-rates.

CHART No. III.



I. ENTERIC FEVER – ADMISSIONS AND DEATHS.


II. MORTALITY FROM OTHER FEVERS — S.C., INTERMITTENT, REMITTENT.
III MORTALITY FROM BOWEL DISEASES — CHOLERA, DYSENTERY, DIARRHŒA = BLACK. WHOLE OUTLINE (BLANK + BLACK) = BOWEL DISEASES + ENTERIC FEVER
RATIOS PER MILLE
ALL CAUSES
ENTERIC AND OTHER FEVERS AND BOWEL DISEASES
IV. MORTALITY FROM ALL CAUSES. THE INCLUDED BLANK SPACE BELOW REPRESENTS MORTALITY DUE TO ENTERIC AND OTHER FEVERS AND BOWEL DISEASES
YEARS
1870 71 72 73 74 75 76 77 78 79 1880 81 82 83 84 85 86 87 88 89 1890 91 92 93 94 95 96 97 98 99 900 01 02 03 04

radically altered, a point which will be discussed fully in subsequent pages; again, the troops were not engaged on field service during this period. And the other salient feature of the record is an equally steady and consistent fall in the rates for simple Continued and Remittent fevers; this, taken along with the marked rise in the Enteric and *total* fever rates connotes, without doubt, an increase in Enteric, and evidence will be adduced presently to show that this is a *real* increase, altogether apart from the influence of the increased youthfulness and shorter service of the human material exposed. Looking more particularly to the *mortality* rates, which constitute the surest test in this question, we may say in brief and broad terms, that while the *total* fever death-rate between 1870 and 1899 had increased by 100 *per cent.*, the Enteric mortality, on the same strength exposed, increased by 200 *per cent.*, or to treble the original amount recorded, and at the same time the death-rate from non-Enteric fevers was reduced to one-half. The decrease in the actual death-rate from the non-Enteric class, roughly 0·7 *per mille*, has only amounted to one-fifth of the rise in the *total* fever mortality, 3·6 *per mille.* It may also be remarked as regards these non-Enteric fevers, that the mortality rates have decreased in greater proportion than the admission (sick) rates, which also goes to support the inference of a nominal transfer of many of the severer cases to the category of Enteric, but some portion of this result has been due, in all probability, to the change in the age and service constitution of the *personnel*, as the mortality from non-Enteric fevers has always fallen most heavily on the older age and longer service periods in contrast to the incidence of Enteric. Doubtless, other factors noted in the previous chapter, and notably improved sanitary measures, have also contributed to the result, though, on the other hand, Influenza which has been constantly prevailing during the last fifteen years would probably tend to affect adversely the non-Enteric fever rates.

As regards the course of the disease in the different Presidencies (or Commands) much the same features are observable, and little need be said at this stage as the local distribution will be discussed fully in a subsequent chapter, but the distinctive characteristic incidence in the different chief areas is very evident. Where occasional departures from these occur, and where large fluctuations are apparent in any single area, we may see the effect of specially large outbreaks in a minority of stations, and as regards Bombay, since 1895, the effect of the transfer of Quetta to that Command from the old Bengal Presidency. Finally, the influence of active service in the field (though the sickness and mortality actually incurred *in* the field are not included in the statement given) is seen in the sudden, and more or less temporary, rise in the rates for both Enteric and other fevers, notably, in 1879-1880 (Afghan War), in 1885-86 (Burmese War), and in 1897-98 (Tirah Campaign). This influence may be held to have operated to produce the exceptionally high rates in the Punjab and Bengal Commands in the quinquennium ending 1899, the troops located therein being most largely employed in the operations, and it will be noted that the subsequent fall in the rates is proportionately much greater in these two areas than elsewhere.

TABLE III.

European Troops in India as a whole.

Mortality (actual numbers of deaths and rates per mille) from Enteric and other Fevers and from specific Bowel complaints; 1862-1900.

INDIA.—Deaths and Death-rates only.

Period & average strength.	Cholera.	Enteric Fever.	"Other" Fevers.	Dysentery and Diarrhœa.	Hepatitis & Abscess of Liver.	Total Deaths. All Causes.
1862-1870 (Str. 59,827)	2,650 4·9	1,589 2·9		1,441 2·6	1,700 3·15	13,020 24·2
	Total 10·4 per mille.					
1871-1880 (Str. 56,213)	1,592 2·8	1,184 2·1	721 1·28	946 1·7	1,145 2·0	10,363 18·67
	Total 7·9 per mille					
1881-1890 (Str. 61,399)	899 1·46	2,342 3·81	431 0·70	546 0·89	816 1·33	8,744 14·24
	Total 6·9 per mille.					
1891-1900 (Str. 68,224)	726 1·06	4,404 6·46	506 0·74	638 0·94	878 1·29	11,058 16·21
	Total 9·2 per mille.					

It will be interesting to supplement the statement just discussed by another (Table III.) which reviews the course of the mortality from "fevers" and from bowel complaints during the last 40 years of the nineteenth century, and which exhibits the predominant place in the death-rates which diseases of the bowels ("filth diseases") have consistently maintained. Fevers other than Enteric find a legitimate place in this table, because, as we know, much true Enteric was formerly included in that category, and beyond this we shall be able to emphasize the results already arrived at in regard to the increased prevalence of Enteric Fever. Chart No. III. should also be studied.

It must be premised that the earlier decades were periods of epidemic outbreaks of Cholera and other bowel diseases, which, excluding Enteric Fever, have been abolished to a very marked extent in recent years. The records show, what decennial averages fail to show, extraordinary fluctuations formerly in the death-rates from year to year and in different localities, but where these occur to-day they are almost entirely due to one cause, *viz.*, Enteric Fever. We see, first, in the foregoing statement a very considerable and fairly consistent fall in the *total* death-rate (all causes), but it is surprising and disquieting to find that the mortality from the specific bowel diseases practically maintains the position it held in what may be called the "pre-sanitary era," and in proportion to the total death-rate there has been a distinct rise on account of these causes from 43 *per cent.* in the first two decades, to 48 in the third and to 56·7 *per cent.* in the last. If acute diseases of the liver be included, as largely dependent on bowel complaints and "filth" causes, the proportions rise from 55·8 to 64·7 *per cent.* of the total mortality. We have, therefore, nothing to congratulate ourselves upon as the result of 40 years' efforts in regard to the class of what are held to be preventible diseases. A glance at the table will show how far Enteric Fever is responsible for the failure we must deplore; several influences have operated to reduce the mortality from all causes as we have seen in the introductory review, but although many of the conditions which favour the prevalence of bowel diseases as a class are also common to Enteric, it cannot be doubted that some point in the etiology of the latter has evaded our circumspection and our efforts. If we confine our attention to the Bengal Presidency, which to make a rough generalization includes the endemic areas both of Cholera and of Enteric Fever, a similar and equally forcible demonstration of this truth is provided.

TABLE IV.

BENGAL PRESIDENCY.—*Death-rates only.*

Period.	Cholera.	Enteric Fever.	Other Fevers.	Dysentery and Diarrhœa.	All Causes.
1862-1870 ...	6·0	3·4		2·7	25·6
	Total 12·1 per mille.				
1891-1900 ...	1·34	7·5	0·84	0·89	17·75
	Total 10·6 per mille.				

Here, again, it is seen that with a reduction in the general death-rate of fully 30 *per cent.* (8 *per mille* of strength) the mortality from specific bowel complaints alone has only receded to the extent of 12 *per cent.* (1·5 *per mille* of strength), and that the place of Cholera in the death-roll, has been taken by Enteric Fever, the *total* fever rate having risen by 5 *per mille*, a fact that can bear no other interpretation than that of a very decided increase in the prevalence of Enteric Fever.

It may be added that the increased prevalence of Enteric Fever demonstrated in the records for the rank and file is also visible in the cases of officers, and women and children attached to the army (see Chapter VI.).

In dealing with the question of the causes of the remarkable rise in the sickness and mortality from Enteric Fever, we have to distinguish between an apparent (recorded) increase and a real increase, and the latter may be due either to an increase in the amount of susceptible *personnel* exposed to risk, which would cause the rates to rise, or to actually increased prevalence among those exposed under similar conditions as to susceptibility. It is well established that the greatest liability to contract the infection is associated with the period of adolescence and early manhood, *viz.*, from 15 to 25 years of age, and we have seen how greatly the actual numbers of men at the 20—25 age-period and the proportion of these to the total force exposed, have increased during the last 30 years. We have a far larger number of susceptible men exposed, and beyond this, owing to the shorter term of service, the stock of susceptibles is more frequently renewed and a larger body of men is brought under the influence of a totally strange environment. There is also the possibility of the effect, already alluded to, of the diminished experience of the disease acquired in recent years by men before they leave the United Kingdom. The probable effects of increased traffic between other endemic centres of the disease and India and between different stations in the country itself (involving the question of importation); of concentration and aggregation of larger numbers of susceptible men; of the long-continued occupation of cantonment sites, and of the conditions incident to the conduct of war and other expeditions beyond the range of ordinary life in cantonments, will be discussed fully in the sequel; but here we shall merely commit ourselves to the conviction that all these are potent factors in the production of a real increased prevalence of the disease. On the more serious question of the greater liability to contract the disease of bodies of men under similar conditions as to age and service, the more important form of "true increase," evidence will be adduced immediately.

Much of the increase as *recorded* has, of course, been merely apparent and due to improved diagnosis and to the transfer of cases from other nosological heads, chiefly those of Simple Continued and Remittent fever. And formerly many cases were lost to the true designation owing to the supposed necessity of arriving forthwith at a diagnosis in every case however recently admitted, in order to complete the periodical official returns, a tag of red-tape that has been long since abolished in India, though it flourished rampant in the American Concentration Camps at the time of the Spanish War (1898). It is obvious that with the improvement of diagnostic methods this source of (apparent) increase must have steadily diminished.

But this at once raises the important question as to what amount of error still clings to the record, as to how far we are still from a complete recognition of the full extent of the disease?

In answer to this question, it has been usual to point to the two outstanding facts, *viz.*, the decrease in the mortality from Continued and Remittent fevers, which, as we have seen, is much greater in proportion than the decrease in the sickness therefrom; and, secondly, to the case-mortality from Enteric Fever itself. And, doubtless, both afford indications of the non-recognition of the disease in gradually diminishing measure from the earliest records down to the present day. The case-mortality of Enteric falls along with the decline in the death-rates from "other fevers"; with these phenomena we have that of a distinct rise in the morbidity from

Enteric. The tables given on previous pages afford evidence as regards the decline in the mortality from "other fevers," but it is to be noted that the result is largely due to the altered age-constitution of the army; the number of men above the age of 30 has been greatly reduced and the older men always exhibit a special liability to die of attacks of Remittent fever. Of the case-mortality in Enteric Fever, it may be said that it has ranged from between 50 and 60 *per cent.* of the cases in the first decade with a more or less consistent decline to 26 or 27 *per cent.* in the last; and, further, as the years proceed there is a very distinct diminution of the excessive fluctuations which mark the returns from separate localities when compared *inter se*, and in the fluctuations in the case-mortality from the same places from year to year. That is to say, that with the rise in the recorded prevalence of the disease there has been a fairly corresponding decrease in the rate of fatality. And, again, it may be said that where Enteric is most prevalent, *i.e.*, in its endemic areas, the case-mortality is consistently, if not very markedly, lower than elsewhere, and, *ceteris paribus*, the larger the cantonment (the greater the aggregation of human material exposed) the lower is the case-mortality, if we except the hill stations where it is invariably lowest. This would indicate that where cases are actually most abundant, the disease is more readily recognized, and it may also be that facilities for nursing and medical attendance generally are there more fully available. The more favourable climatic conditions of the hills may be held to explain the exceptional results reported therefrom, and the significance of the prevalence of the disease in these stations will be dealt with subsequently. The subject of case-mortality, as providing indications of the more or less complete recognition of the disease, is of sufficient importance as to demand more than passing allusion.

Of course, it is true of India as elsewhere, that while the rate of attack gets lower as we pass from the most susceptible age and service periods (age 20-25 and the first two years in India) to the later periods, the case-mortality rises and therefore we should expect a lower case-mortality on the cases reported from the army as a whole with the increased proportions of youthful men and of those of shorter service, apart from improvement in the extent of the recognition of cases. This consideration must not be left out of account in an endeavour to estimate the extent of the ground gained. It may be as well to place on record the facts regarding the case-mortality during recent years, as this is affected by the age and service factors; and we shall compare two periods of three years each, in the former of which the army had included a far larger proportion of young and newly-arrived men than in the latter period.

TABLE V.

Case-mortality per cent. at different Age and Service periods.

(*a*) By Age.

	Under 20 yrs.	20-25	25-30	30-35	35-40	40 +
Army of 1896-98 C.-M. *per cent.* ...	22	27	26	37	45	—
Army of 1900-02 C.-M. *per cent.* ...	13	28	27	37	53	25

(*b*) By Length of Service in India.

	Under 1 year.	1-2	2-3	3-4	4-5	5-10	10 +
Army of 1896-98 C.-M. *per cent.* ...	24	29	28	30	32	29	33
Army of 1900-02 C.-M. *per cent.* ...	25	28	30	26	28	30	43

The case-mortality *per cent.* for all ages and periods of service was in the former triennium 26·8 and in the latter, 27·2. Now this fatality rate is very much higher than that recorded in the returns of European hospital practice, which for the combined 15—45 age-periods may be put at about 10 per cent. (Curschmann), and it must be remembered that probably only the worst cases are admitted to hospital, and these only after the disease has run a considerable part of its course. And then, again, the proportion of young adults in the civil population, among whom the case-mortality is almost at its lowest, is very much smaller than it is in the army, and this factor greatly influences the fatality rate from the whole body at the combined age-periods. Only 9 *per cent.* of the civil male population of England and Wales at the Census of 1901 were included in the age-period 20—25 years, whereas in the army of India the proportion to total strength at this age has, for many years, reached 50 *per cent.* and over : if we take the 15—35 age-periods combined, the relative proportions in the civil population at home and in the army in India, stand at 37 and 93 *per cent.* respectively. If we look to the results obtained in the American Concentration Camps in 1898, we find that of 4,293 cases recognized on first admission 391 died, a mortality of 9·1 *per cent.*, but if *all* the cases, including those subsequently considered to be true Enteric be taken into account, the case-mortality is reduced to 7·4 *per cent.* As the age-constitution of the forces was probably approximately similar to that of the Indian army, we may conclude that the rate of fatality is about three times as great in the latter body as it was in the former. It may be added that during the quinquennium 1898-1902 the case-mortality recorded among the European troops stationed in Egypt and Cyprus was 26 *per cent.*, in Malta, 29 *per cent.*, in South Africa, during the Boer War, it was 19 *per cent.*, so far as the figures at present available show ; but in 1898, 1899 and 1902, before and after the war it was only 13 *per cent.* in South Africa. Hitherto we have been dealing with the rank and file of the army, and we may complete the statement by saying that, for the combined period 1895-1902, the case-mortality among the European officers, women and children in India was 21, 33 and 12 *per cent.* respectively.

It is obvious that if a considerable number of cases be unrecognized, the rate of fatality will be raised, but there are doubtless other factors in operation to produce the results. Among the most potent of these are what we may call climatic influences, the lowered resistance due to previous or concurrent attacks of Malarial fever and Dysentery, &c., and the predisposition to cerebral apoplexy, to visceral congestions and to nervous exhaustion. The records of the American Camps show that where Malarial fever actively complicated an attack of Enteric, which was rare (12 cases in all), the case-mortality rose to 33 *per cent.* The much lower fatality in the hill stations which may be put in recent years at 19 *per cent.* against 27 for the plains stations, is a fairly sure indication of the operation of climatic influences to which may be added the depressing effects of exile and all it connotes. There can also be no doubt that the practice of changing the designation of the disease, when it is only recognized *post-mortem*, has also served to swell the case-mortality, but this of course implies that some cases that recover do escape due recognition. But a still more potent and practically important influence in raising the mortality is the disinclination of the men to report themselves as unwell until a late stage in the progress of the disease, for the time at which careful treatment is begun is a cardinal point in the prognosis and in the results achieved. In discussing the etiology facts will be adduced to show how indifferent the men are to the first symptoms of the disease and at how late a stage they come under treatment. We see then how both the lowered resistance of the subjects of infection and the conditions of the environment doubtless co-operate to raise the case-mortality; as to whether the third factor, the causative agent, *i.e.*, the specific bacillus, has special properties of virulence in this country for Europeans, nothing certain can be said, but the subject will be touched upon later. It is also impossible to appraise the influence of these various influences, but we shall affirm the opinion that they do not account for the whole of the excess which the records exhibit, and that, therefore, an uncertain proportion of cases is still overlooked. This view derives support from the results obtained in civil practice; during the years 1894-1895 the civil surgeons of Bengal, the N.-W. P. and the Punjab had under their care 168 cases of Enteric among the Europeans resident in those areas; of these 168 attacks 24 proved fatal, giving a case-mortality of only 14 *per cent.*

Lastly, a most careful and reliable observer, von Drigalski, computes the average case-mortality among the population where the disease is endemic at not more than 5 *per cent.* all round, and he takes this estimate as the measure of true prevalence in an affected area in Europe. It has already been stated that one-fifth of the whole number of men concentrated in the American Camps for the Spanish War was attacked, and the Commission appointed to enquire into the subject estimated that when the disease becomes epidemic in a Command, no less than one-fourth to one-third of the troops will be found to be susceptible to the infection, an opinion framed on the numbers attacked in various bodies of men and on the assumption of the exhaustion of the susceptible material thereby attained

Now while admitting that the conditions are less favourable to recovery in India, and that we cannot reasonably compare the case-mortality with that experienced in Europe and America, it is a striking fact that, on the recorded admission rates, only one man in twenty at the most susceptible age and service periods should be attacked in this country, during the worst periods of its prevalence. It is difficult to account for this large measure of "immunity" on the assumption that the records are complete.

The recent use of the Gruber-Widal reaction has not availed in practice, to decrease, in any marked degree, the difficulties that beset the differentiation of the disease from other fevers that present a somewhat similar clinical picture, and that diagnosis is based chiefly on clinical and *post-mortem* signs. Indeed, it has frequently been reported that a negative result of the test has served as sufficient reason for the exclusion of doubtful cases from the diagnosis of Enteric, which, in the absence of the test, would have been returned as such. During the last five years, of 48 specimens of blood from suspected cases, tested at one laboratory (Agra), only 11 gave a positive reaction, a percentage of just under 23. At the same time it is true that the test is applied in a minority of the cases only, and the conditions under which it is made are not always beyond reproach, *e.g.*, a negative result in the early stages, if unconfirmed by subsequent observations, may well lead to fallacious conclusions. (See Chap. III.)

Evidence from another side may be obtained from a comparison of the seasonal incidence of Enteric in comparison with that of Simple Continued and Remittent fevers and of Dysentery and Diarrhœa. Although, as will be seen (Charts, Chapter IV.) the seasons of *maximum* prevalence of these latter diseases do not, as a rule, coincide with that of Enteric Fever, there are very suspicious and suggestive rises in their curves which synchronise with the periods of increased Enteric prevalence. We shall also find some evidence of an inverse relationship between the recorded local distribution of these other fevers and that of Enteric, but this is by no means complete nor uniform as, indeed, might be expected; for if under the designation of Remittent or Continued fevers, cases of real but modified Enteric are included, the local incidence of all three forms should coincide to some extent. In this connexion reference may be made to the experience of most capable observers in the American Camps of 1898, who found that the Continued and so-called "Malarial" fevers reported were almost entirely true Enteric, and specific data are afforded in detail for this conclusion. Apart from the positive testimony of the Widal test and the negative results of blood examinations for the *hæmamœba*, the most interesting fact was strikingly demonstrated that previous attacks of these other fevers conferred a very large measure of immunity from Enteric Fever. In a body of 18,749 men of whom 4,042 had been treated for "Malarial fever," 127 or 3 *per cent.* were subsequently attacked by Enteric, whereas among the remaining 14,707 men of the same body unaffected by "Malaria," there were at the same time, 3,290 cases of Enteric, equal to over 22 *per cent.*, and very similar results are recorded in regard to antecedent bowel diseases. These facts must however be discounted in their application to India, where true malarial fevers are much more rife. The results of the application of the Widal test to cases of so-called Simple Continued fever during the South African War are said to have indicated that no less than 75 *per cent.* of the sickness as recorded on this account was due to true Enteric infection. (Crombie, *B.M.J.*, September 14th, 1901.) It is quite possible that the older and more resistant men may acquire the true infection in this modified form, and we shall see later how various are the clinical appearances presented in a single body of individuals to which the specific virus has gained access from one indubitable source at the same time, as in an outbreak from contaminated water. A report on the so-called "Remittent" or "Pretoria" fever, occurring among the troops in the later stages of the South African War, furnishes additional evidence in this connexion. These cases were as a rule of less than 13 days' duration; the majority of the subjects attacked had served in the country for over eighteen months, and many of them had previously passed through attacks of true Enteric; the clinical symptoms pointed most definitely to intestinal implication, no plasmodia were detected in the blood, and there was a decided tendency to relapses. Of a series of eleven of these cases seen by one observer in one month, all are said to have given a positive reaction by the sedimentation test. (Tyndale, *B.M.J.*, February 15th, 1902.)

The average number of days in hospital for cases of Simple Continued fever in India is just over 17, and for Remittent fever, 26 days; the former disease is usually ascribed to "chill," exposure to direct heat of the sun, and to errors in diet; the latter to one or other form of the Malarial parasite, the diagnosis of which is rarely substantiated by the microscope. Lastly, we find the case-mortality of Enteric Fever at its highest, and markedly so, in the period from May to October, inclusive, which is when these other anomalous fevers are most rife, and this is suggestive of non-recognition of cases, although it must be admitted that climatic influences are most unfavourable for recovery at that time. It is also noticeable that the case-mortality of Remittent Fever rises to its highest point at the time when Enteric is most prevalent; and, further, a study of the *post-mortem* reports of fatal cases of "Remittent" reveals the frequent occurrence of Pneumonia, of abscess in different tissues and organs, and occasionally of Meningitis, all very suggestive of true Enteric infection. In the two years 1902, 1903, there were altogether 22 fatal cases of Remittent Fever recorded among the rank and file in India; eight of these patients had less than one year's service in the country; one of these was 26 years of age, the other seven all being below that age.

To sum up; while it is indubitable that other forms of fever, etiologically distinct from true Enteric, prevail, all the evidence goes to indicate that whereas formerly, as will be shown immediately, there was really less Enteric Fever, this was made to seem still less by non-recognition and failure of diagnosis, while, recently, with a true increase of the disease, the record is augmented, in comparison with the past, by completer recognition of cases; but that even now there is an uncertain proportion of failure, especially in regard to the light, ambulant forms and those cases of true infection which produce no obvious morbid results. It is unnecessary to emphasize the serious import of the conclusion in its bearing on the propagation of the disease and on the whole epidemiological problem; we have, moreover to take into account the manifold uncontrolled sources of infection arising from recognized cases, at some stage, before and after they come under treatment.

We have now to deal briefly with the evidence that may be adduced to indicate a *true* increase in the prevalence of the disease altogether apart from the change in the age and service-constitution of the *personnel.* It is not only, in plain terms, that the recent records show a far larger number of cases and deaths annually in proportion to strength than formerly, simply because there is a larger amount of susceptible human material exposed to risk, but that both the risk of infection is itself greater, and its results more abundant, when the sickness and mortality from the disease are compared in two bodies of men similarly circumstanced in regard to their age-constitution and length of Indian service, but who differ solely in respect of the period at which they were exposed to this risk. It is obvious that to elucidate this point, we must confine attention to the mortality rates as recorded for all forms of "fever" which can be reasonably held likely to include Enteric Fever; there can be no suggestion that Enteric Fever is now more fatal in proportion to the attacks than formerly, and the same assumption holds good for the other so-called Remittent and Continued forms. Indeed, the probabilities are all on the other side, and this lends a special significance to the steady rise in the combined death-rate from "fevers," which has already been brought to notice. (Tables II. and III.) It has been shown that the mortality ascribed to "fevers" in the army of India as a whole, has risen from 2·9 *per mille* in the period 1862-1870 to 7·2 in 1891-1900, an increase of 4·3 *per mille*,* or to about 2½ times the former rate; in the Bengal Presidency taken alone the rise has been even greater, *viz.*, from 3·4 to 8·34 *per mille*, but the relative increase is about the same. If the mortality from Dysentery and Diarrhœa be included in each case, we still find an increase in the combined rate which is equivalent to 50 *per cent.* on that of the earlier period, an increase which is arrived at by a steady progression through the decades and which is not associated with a similar and synchronous increase in the number of young and newly-arrived men. But this latter concession (the inclusion of the bowel complaints) is obviously excessive; a small minority of such cases may indeed have been of the true Enteric class, but wholesale confusion in the matter is beyond the range of possibility, and we have the cogent evidence of the records of the native army and the prisoners to the fact of the remarkable reduction in the death-rates from these bowel complaints, which has been even greater than in the European army, and among whom there can be no question of confusion with Enteric. This marked decline in the mortality from bowel complaints with the great diminution in the *morbidity* from "fevers" as a class, along with the rise in the *mortality* of the latter are the central features of the situation, of which no appeal to the altered character of the *personnel* exposed will avail to provide a complete explanation.

*Death-rates from Fevers including Enteric.

	per mille.
1862-70	2·90
1871-80	3·38
1881-90	4·51
1891-1900	7·20

But in order to exclude the operation of an uncertain factor it will be well to compare the records furnished from bodies of men under similar conditions as regards their age and service composition. And, first, some indication may be derived from a statement extracted from the returns of the army in occupation in the period just following the Mutiny, in the pre-sanitary era, before the Royal Commission was appointed (1863), the labours of which form a landmark in the sanitary history of the forces. This army was, as has been shown (Chapter I.), almost totally new to the country and it included a higher proportion of men under the age of 25 years than has hitherto ever been attained under the short service system. The conditions of the life of the soldier in India at that time were immeasurably harder and more inimical to health than they have since been rendered, but for the period 1859-1863, the average annual death-rate recorded for all forms of "fever" was 4·45 *per mille* and for Dysentery and Diarrhœa combined, 6·51, or 10·96 for "fevers" *plus* specific bowel complaints, excluding Cholera, the total death-rate being at the rate of 36·9. In 1891-1900, the mortality among the troops occupying the same area was, from Enteric 7·5 *per mille*, for other fevers, 0·84, or 8·34 *per mille* for all fevers, while for Dysentery and Diarrhœa it was 0·89, a combined rate for all these specified causes of 9·23, of which Dysentery and Diarrhœa account for less than one-tenth, against a proportion of six-tenths in the previous period. If we may not arrive at a sound conclusion by simply contrasting the combined "fever" rates, *viz.*, 4·45 against 8·34, it is equally certain that only a very small proportion of the mortality from Dysentery in the former period can be ascribed to true Enteric, for the mortality from Dysentery was highest, in direct relation to the age of the men, taking the reverse course to the incidence of Enteric Fever in this respect. The conclusion then must be, when all allowances are made, and considering the conditions to which the army was exposed just after the Mutiny, when non-Enteric Fevers were so much more fatal, that true Enteric was probably less than half as prevalent at that time among a large body of men of approximately the same age-constitution, and under far less favourable hygienic conditions. A clearer and even less doubtful demonstration of the facts will be obtained, if we take the records of the newly-arrived regiments (1864-69), during their first year of service and compare the results with those of the army of India as a whole some thirty years later. The proportion of young men (under 25 years of age) in the contrasted bodies is almost identical, *viz.*, 52·3 and 54·6 *per cent.* respectively of the total force represented. But in another respect the evidence will be "weighted" to the disadvantage of our contention inasmuch as the newly-arrived regiments (1864-69), served in the Bengal Presidency, where, as we shall see, Enteric Fever is most prevalent, while the contrast is made with the army located throughout India, including areas where the disease exhibits the minimum incidence and is frequently entirely absent. It may be noted that the average strength of the newly-arrived regiments in their first year of service was 14,802, a sufficiently large body to allow of reasonable comparison.

TABLE VI.

Death-rates per mille in the first and second years of service in India.

	New Regiments, 1864-69.		Army of India, 1895-99.	
	Under 1 year of service.	Between 1 & 2 years' service.	Under 1 year of service.	Between 1 & 2 years' service.
"Fevers" (Intermittent, Remittent and Simple Continued).	8·03	5·12	0·49	0·48
Enteric Fever ...	Not differentiated	from "fevers."	15·06	8·49
			15·55	8·97
Dysentery and Diarrhœa.	4·05	2·39	1·33	1·02

The mortality from "fevers" (combined rate) is thus seen to be 7·52 *per mille* higher in the recent period, for men of one year's service 15·5—8·03, an increase of 93 *per cent.;* while for men in the second year of service it is higher by 3·85 *per mille*, an increase of 75 *per cent.* over the rate of the former period.

In a similar way one more example may be given from the records of the newly-arrived regiments, and during their first year of service, for the period 1871-75, by which time Enteric Fever had taken its place in the returns, but here of course, as before, the comparison will be made between the *combined* fever rates, including Enteric. The average strength of these newly-arrived corps was 21,872, and they were located in the Bengal Presidency.

TABLE VI*a*.

Death-rates per mille in the first year of service.

	New Regiments, 1871-75. First year of service.	Army of India, 1895-99. First year's service.
"Fevers" (non-Enteric as above) ...	1·70	0·49
Enteric Fever	6·26	15·06
Total "Fevers" ...	7·96	15·55
Dysentery	1·78	1·33

The increase in the mortality from fevers (7·59 *per mille*) is equal to 95 *per cent.*

It will be admitted that these figures are susceptible of only one interpretation as regards the main question before us. It is indeed possible, even probable, that in the earlier period some deaths from true Enteric Fever were ascribed to such causes as Peritonitis or Meningitis, but on the most liberal estimate of the extent of the error thus involved, an ample margin of excess in the mortality from Enteric in recent years would remain to establish the truth of our contention of a real and marked increase in the disease, altogether apart from the change in the *personnel* of the army. There can be no question of the cardinal importance of the personal factor as will be shown subsequently, and as, indeed has been made clear in the foregoing pages, and it may be well to forestall an objection that may be raised to the choice of the later period employed (1894-99) in the demonstration of our thesis in view of the subsequent decline in the following, *i.e.*, the last, quinquennium. This decline may be reasonably ascribed, in largest measure, to the change in the *personnel* in the reverse direction, to the larger proportion of men at the higher age and service periods and to the absence of new arrivals owing to the suspension of drafts and reliefs during the Boer War. But an analysis of the returns during the decline shows, beyond all question, that young men coming direct from Home at the susceptible age, and exposed for the first time to the conditions of life in Indian cantonments, are far more liable to contract and succumb to the disease than formerly. For instance, during the year 1902 when the death-rate (India) from Enteric Fever had fallen to 4·29 *per mille*, the average strength of newly-arrived drafts from the United Kingdom, having less than 2 years' Indian service, was 5,906, and among these there were recorded 351 cases and 91 deaths from this disease alone, giving rates *per mille* of 59·4 and 15·41 respectively, whereas the combined death-rate from all fevers including Enteric, of men similarly circumstanced in 1871-75 was only 10 *per mille*. And throughout the consideration of this question, it is necessary to bear in mind that under the conditions existing in the pre-sanitary era, the period with which we are comparing the most recent results, the mortality from non-Enteric Fevers of all kinds and of specific bowel complaints was much greater than it is to-day, and consequently the marked and progressive reduction therein lends special force and significance to the striking rise in the fatality of all fevers as a class in recent years. No question of the etiology of these fevers in the past can obscure the plain indication of these facts, in the light of present knowledge.

Some further confirmation of this contention in favour of a true increase in the disease with the progress of the years is afforded by the altered course of the incidence of mortality (all causes) on the age and service periods. Formerly, the rates increased in direct proportion to age and service, while now the reverse relation is observed (save only that the 20-24 age period is most fatal). Much is due to the suppression of the chief causes of mortality falling on the higher ages and service periods and to the altered age and service-constitution of the army, but the contrast is too striking to be thus completely explained.

The all-important bearing of this conclusion on the etiological problem will be rendered clearer from another point of view. It is very significant that there is good evidence to show that many cantonments which, as will be seen later, now stand foremost in the list of endemically-infected centres, were formerly free, or comparatively free, of the disease. Thus Bryden gives as an example the case of Poona where four *new* regiments were stationed during 1871-75, and these had recorded death-rates, from all causes, ranging from only 4·5 to 13 *per mille*; there were only three fatalities from "fever" among the four corps in the course of four seasons, and no approach to this immunity can be found in the records of recent years.* Bryden who is

* It is mentioned incidentally, that one of these corps which landed in April, included "539 boys, out of a total strength of 897"

discussing the local prevalence of Enteric Fever, proceeds to advert to the healthiness, for newly-arrived troops, of Bareilly, Umballa and Bangalore, all of which have subsequently attained an unenviable notoriety for the disease, and a study of his reports on the statistics of the decade 1860-69, and of the following six years, in which the returns from individual cantonments are given, leaves a forcible impression of the contrast between the past and present conditions of most of the localities now constantly associated with high Enteric incidence. These facts, upon which we may not dwell longer at this point, are scarcely consistent with the view of ubiquitous sources of infection at that time among the native population, and within and in the neighbourhood of, cantonment sites, *i.e.*, in native bazaars and contiguous towns. If the arguments here adduced be valid, some new and potent source of the disease must be postulated to account for its increased prevalence, and we can scarcely fall back upon the explanation put forward in the Report of the Army Medical Department for 1902 that the natives of the country "are saturated with the disease," without making some attempt to appraise the evidence and to discriminate the various factors that have been in operation. Some of these have been briefly reviewed (Chapter I.), and their application to the problem will form the subject of discussion in the ensuing pages, but without prejudging the case, it may be affirmed that whatever be the "power" we may subsequently assign to the factor of infection from direct or indirect contact with the Native environment, this at least has not varied appreciably unless, indeed, we can regard the continued presence of a European element in its midst as a modifying influence.

It remains to add, in connexion with the subject of this section, that with the progress of the years there has been a marked tendency to an increased incidence of Enteric Fever on the higher age and longer (Indian) service periods of the force exposed. The facts bearing on this phenomenon will be given later (Chapter III.) ; here, it is merely necessary to state the broad indication it connotes ; we must assume some change either in the powers of resistance of the older men, or in the virulence or abundance of the causative agent, together with greater facilities of effective access of the one to the other. It may be that men sent to India in recent years have less natural or acquired resistance to the infection owing to absence of experience of the disease before leaving home, where with the progress of sanitary measures the prevalence of Enteric Fever has greatly decreased ; fewer have doubtless suffered previous attacks in childhood or early youth, and the race as a whole may have become more susceptible owing to the non-elimination of the most susceptible subjects who would, in former times, have died before the age of marriage, but who have survived to hand on their susceptibility to their children. As regards the other factor, we know that there has been increased risk of infection from the increase in the amount of the disease and, consequently, of the sources of infection, and with the increasing numbers of young men attacked from year to year, there may have been an exaltation of the infectivity of the virus. It is not, however, impossible that improved diagnosis has had some effect on the *record* in the case of the older men, who are naturally less susceptible to the disease and among whom anomalous cases are likely to occur, and these, if unrecognized, must prove a special source of danger to others. But that this is not a valid explanation of the full measure of the change is evident from a comparison of two most recent periods, *viz.*, of that immediately preceding with that during and after the Boer War when the age and service-constitution of the army was in strong contrast. There was no interval to allow of radical improvements in diagnosis, but the increased incidence of the disease on the older men and on those of longer service in the latter period is most marked.

TABLE No. VII.

Enteric Fever. Admissions per 1,000 *and Liability at each Age-period.*

	Under 20 years.	Years 20-25.	Years 25-30.	Years 30-35.	Years 35-40.	Years 40 +
1896-98, Ratios ..	27·6	43·1	17·4	6·9	2·6	......
Liability ...	28·28	44·16	17·83	7·07	2·66	......
1900-1903, Ratios ...	16·4	25·1	11·4	5·6	3·6	2·9
Liability ...	25·2	38·6	17·5	8·6	5·5	4·5

TABLE No. VII.—*contd.*

The same for each Indian Service-period.

	Under 1 year.	Years 1-2.	Years 2-3.	Years 3-4.	Years 4-5.	Years 5-10.	Years 10 +
1896-98, Ratios ...	74·0	32·9	24·0	18·5	16·1	10·4	1·6
Liability .	41·69	18·54	13·52	10·42	9·07	5·86	·90
1900-1903, Ratios	40·5	23·9	14·5	11·1	10·4	9·5	3·4
Liability ..	35·7	21·1	12·8	9·8	9·2	8·4	3·0

The full significance of the contrast will only be appreciated when the marked decrease in the rates for all ages and service periods in the latter of the two combined periods is taken into account; the admission rate for the former period was 30·2 and for the latter only 16·4 *per mille* of total strength, and with a very marked decrease in the earlier age and service periods there is an increase in the last two periods, so that the *relative* rise in the incidence on the latter is really very considerable, as, indeed, is shown by the relative "liability" rates. The phenomenon is not confined to the incidence of Enteric Fever only; it must be referred to causes inducing an enhanced liability to nearly all forms of sickness at the later age and service periods, which the records of the last few years exhibit (see page 47), and this is probably to be attributed to the more prolonged exposure of a larger number of men to the environment.

At the same time, it is necessary to allude to another factor that has been invoked to account for it, *viz.*, "epidemic influence." It has been shown that, both in South Africa and in Bermuda, the incidence and liability on the later age and service periods is notably raised during years of epidemic prevalence, and it has been suggested that "there is a certain relation between the degree of susceptibility and the intensity of the contagion," an increase in the latter being accompanied by an increase in the number of attacks of older men and of those with longer residence. (Major Simpson in A. M. D. Report, 1898, Appendix VI.) This is only another way of stating the case of an enhanced virulence of the disease-agent on the one hand and of lowered resistance on the other hand. But if the table just given be studied, there is, apparently, little, if any, support to be derived from the facts in favour of an epidemic influence, so far as India is concerned. The period 1896-98 with a combined admission rate of

30·2, had a far more epidemic character than that of 1900-03, with a rate of 16·4, and yet the actual amount of sickness and the liability was notably greater in the later age and service categories during the latter period.

This brings us, in conclusion, to the striking features of the last few years of the record, *viz.*, the sudden decline in the rates which commenced in 1899, and which touched in 1901 the lowest point attained since 1877, to be followed by the steady rise which has marked the last three years and which is far more definite as regards the morbidity (see Chart, p. 22). These phenomena provide an important key to the etiological problem, and as they will be referred to frequently in the course of the subsequent discussion, we shall briefly summarize the chief factors which may be regarded as operating to produce these results.

There was little change in the age and service-constitution of the forces exposed in India in 1899; the number of men arriving as drafts and reliefs in the winter of 1898-99 was apparently the same as that of the previous trooping season, but only one regiment arrived direct from England, the others coming from South Africa and Singapore. There can be little doubt that the decline in the rates must be attributed largely to a return to normal peace conditions after the Tirah frontier campaign, and this would enhance the significance of the excessive prevalence of the disease in the preceding years as depending largely on the importation of the infection by the troops returning from active service. The decrease in 1899 was most definitely marked in those areas (the Punjab and Bengal Commands) where the rates were highest in 1897-98, and which had had the closest relations with the campaigns in question, and we must regard this decrease as evidence of a return to normal conditions of risk of a body of men from whom a considerable number of susceptible subjects had been eliminated; and, for the rest, we must invoke the influence of the great falling-off in the number of new arrivals from the United Kingdom.

In the two following years as the result of the Boer war, no new regiments arrived in the country, and the number of drafts fell to nearly one-fifth (in 1899-1900) and one-third (1900-1901) of the average annual supply; the more mature and time-expired men were detained in India, and the whole age and service-constitution of the army was radically altered. During the period 1896-98, the proportion of men under 25 years of age had been 55 *per cent.* of the total, and of those under two years of Indian service, 36 *per cent.*, whereas in 1900 and 1901, these ratios fell, respectively, to 45 and 42 for the age proportions and to 21 and 15 for the service proportions. The change in the character of the *personnel* will be seen to have been much greater in regard to the proportions subjected to the first experience of the environment, and it must be noted that a large number of the men included in the age period (under 25 years) must have been exposed throughout the series of years from 1897 to 1901 to leave, year by year, a constantly diminishing number of the most susceptible subjects. The decline in the incidence of the disease is consequently proportionately greater than the change in the age-constitution would account for, and we must look rather to the previous elimination of the most susceptible and to the greater change in the early service-constitution to explain the results.

In 1902 the drafts and reliefs were resumed and have since been maintained to an extent beyond all precedent ; no less than 22 regiments arrived in the country during the trooping seasons of 1902 and 1903, and the proportion of men under 25 years of age rose in the latter year to 51 *per cent.*, and of those having less than two years' service to 43 *per cent.*, the latter figure representing the highest point ever attained. If first exposure to the environment be the chief factor in predisposing to infection, as indeed, will be shown hereafter, the question arises as to why the incidence of the disease has not risen in proportion, the morbidity rate in 1903 being approximately equal to that of 1899 when the decline from the maximum occurred. There appears to have been some controlling factor in operation during the last three years ; the rates have risen, and are rising, but not in proportion to the renewed youthfulness and inexperience of the forces. The answer must be that the experience has been gained elsewhere ; of the 22 regiments referred to as arriving during 1902 and 1903, no less than 17 came from South Africa, one each from Hongkong, Egypt and Malta, and only two from England. Moreover, as will be shown subsequently, the incidence of the disease on the drafts arriving direct from England during these years was almost as heavy as it has ever been in the period of greatest prevalence.

It should be observed that similar results as regards the influence of previous experience are reported from the Colonial garrisons. It has been shown by Major (now Colonel) Simpson, R.A.M.C., that there is a great difference in the prevalence of the disease among units arriving in Natal according as they arrive (1) direct from England, (2) from the Cape, (3) from India. The admission rate furnished by a body of 4,232 men in category (1) was 39·3 per 1,000; among 3,223 men in (2) it was 33·2 per 1,000, while 3,048 men from India (3) suffered at the rate of only 23·6 per 1,000. Again, in the experience of Bermuda, it is found that corps arriving from Malta suffer notably less than those coming direct from England. The annual prevalence appears to depend on the length of time the majority of the garrison have served in Bermuda and upon the locality in which they previously served. Previous residence in countries where Enteric Fever is endemic confers a degree of immunity, which is roughly proportional to the prevalence of the disease in those countries. And it may be taken that annual variations in the prevalence in the same place or area are largely the result of variations in the degree of protection acquired; and conversely. This, of course, is largely due to previous elimination of susceptible subjects and to the fact that the individual powers of resistance vary, the most susceptible being generally, attacked on the first opportunity. We have also to take account of the probability of a certain relation between the degree of susceptibility and the intensity of the quality of contagion.

Thus, it will be seen that in all enquiries into the effect of age and length of Indian service on the prevalence of Enteric Fever, in all studies of its general course, its local and seasonal incidence, we must take account of certain essential factors, if we would avoid fallacy. Age is, of itself, undoubtedly one of the most important of these, but previous experience both of the environment generally and of the disease in particular is still more important, and these factors may co-operate or be opposed to a greater or less extent. Two bodies of men of similar age-constitution will react very differently to Enteric infection according to their previous experience and as to whether it is acquired in England, or in tropical or sub-tropical garrisons, or in India itself. We have not only to take account of the previous elimination of the most susceptible subjects in the one case, but also of the supply of new and susceptible individuals in both cases;—of the extent and frequency of the renewal of the susceptible *personnel*, both as regards the greater risk incurred by the constituent individuals, and as regards the number of centres of infection thus provided to the detriment of others. These considerations have a further application, *viz.*, to the contention that has been advanced on good authority, that if men were not drafted into the country until they had attained the age of 25 years, there would be very little Enteric Fever: and again, that first exposure to the environment operates simply and solely because "the chief age susceptibility concurs with recency of arrival in India." Evidence in controversion of these views will be adduced in due course, but in connexion with the important phenomenon of the decline in the prevalence of the disease during the last few years, a few remarks are called for. We may examine, in the first place, the position as regards all causes of sickness by comparing the liability thereto at each age and service period during the years 1895-1898 and 1900-1902, thus:

TABLE No. VIII.

Liability to Morbidity from All Causes.

Age Contrast.

	Under 20 years.	20-25 yrs.	25-30 yrs.	30-35 yrs.	35-40 yrs.	40 yrs. +
1895-1898 (Younger Army)	20	30	21	11	9·9	9·6
1900-1902 (Older Army)	18·5	25	22	13·6	9·3	11·0

Service Contrast.

	Under 1 year.	1-2 yrs.	2-3 yrs.	3-4 yrs.	4-5 yrs.	5-10 yrs.	10 yrs. +
1895-1898 (Shorter service) ...	18·6	17·0	16·0	14·6	13·6	14·0	6·4
1900-1902 (Longer service) ...	19·0	16·4	15·0	14·3	13·3	14·5	7·8

The reader is now referred to the similar Table showing the data for Enteric Fever on pp. 42-43. It will be seen that while the extent of the liability at the different age periods varies, the general course is very much the same in both statements, and that the influence of the higher age-constitution of the army in the latter period (1900-02) has not been confined to Enteric Fever, but has operated to alter the proportional incidence of all causes of sickness in a remarkably similar way. As regards service in India, the one point in common is the steady decrease in liability from period to period, but in the case of Enteric Fever the curve is very steep, the contrast between the first and second and the last periods being much greater than that exhibited by all causes. All the facts tend to indicate that the relations subsisting between age and length of service and Enteric Fever are more special and intimate than is the case with the other causes of sickness to which the soldier is liable, and further, that the influence of length of service (previous experience) is still more pronounced than that of age in regard to the former disease.

It is, however, important to remember that both influences operate in a similar, though minor, degree on some of the other chief causes of sickness, and notably on those which are associated with life in the tropics, *viz.*, fevers and bowel complaints. We find that the rates for admissions (from all causes *excluding* Enteric Fever) follow precisely the same course through the different age and service periods, and which, in its whole tendency, is diametrically opposite to the course of the morbidity exhibited by the civil population in its natural environment. The *mortality* rates in the army, however, present a striking contrast, for these rise steadily in direct relation to age, whereas they fall from a comparatively high point in the first year of service through each succeeding year of exposure up to the fifth, after which period there is a rise to the highest point which is maintained to the end of the term of residence. These facts are significant of the potent influence of first exposure to the alien environment, and they confirm our contention in regard to Enteric Fever, in enabling us to exclude, in regard to other causes, the complicating element of age influence to a sufficient extent. Beyond this, the practical bearing is important. In the first place, we see predisposing influences at work in greatest force at precisely the periods of greatest liability to Enteric Fever, which affords a clue to the etiology of the disease. And from this aspect the whole problem of the health of the army is unified while its scope is widened. This will be rendered clearer by an analysis of the returns as regards the incidence of the chief causes of mortality and invaliding on the different age and service periods, the results of which may be summarized thus :

The chief causes of Mortality and their special incidence.

Lower Age.	Shorter Service.
1. Enteric Fever.	1. Enteric Fever.
	2. Malarial Fevers (1st & 2nd years).
	3. Dysentery.
	4. Nervous Diseases.

* * * * * * * *

Higher Ages.	Longer Service.
1. Malarial Fevers.	1. Malarial Fevers. (5th & 6th years).
2. Dysentery.	———
3. Alcoholism.	3. Alcoholism.
4. Tubercle.	4. Tubercle.
5. Nervous Diseases.	———
6. Circulatory Diseases.	6. Circulatory Diseases.
7. Pneumonia.	7. Pneumonia.
8. Other Respiratory Diseases.	8. Other Respiratory Diseases.
9. Abscess of Liver.	9. Abscess of Liver.
10. Urinary Diseases.	10. Urinary Diseases.

Now Malaria, Dysentery, Alcoholism and Venereal disease are responsible for the higher mortality during the later age and service periods from, practically, all the causes numbered 4 to 10 on the list, but the first-named are precisely the morbid influences to which the men are most subject in the earliest periods of their service in India. The problem of an efficient army is the prevention of the chief causes of sickness and mortality, not only for the direct and immediate results in promoting efficiency and reducing cost, but with a view to the indirect and subsequent gains in the reduction of the loss at the later ages. The impairment of resistance due to sickness in the early years, apart from the direct loss in death and invaliding, affects to a very material degree, the loss in later years. The problem, therefore, resolves itself practically into that of the prevention or reduction of Enteric Fever, Malaria, Dysentery and Venereal Diseases which fall so disproportionately on the earlier periods of service, but which affect the later age and service periods so disastrously. This is confirmed by the facts as to the chief causes of Invaliding at the higher ages and after longer service, thus :

	Higher Ages.		Longer Service.
Chief Causes.	Dysentery.	Chief Causes.	Dysentery.
	Malarial Fevers.		Malaria.
	Venereal Disease.		Venereal Disease.
	Debility.		Debility.
	Tubercle.		Tubercle.
	Hepatitis & Liver Abcess.		Hepatitis & Liver Abscess.
	Rheumatism.		Rheumatism.
	Mental Diseases.		Mental Diseases.
	Heart Disease (Valvular).		Heart Disease (Valvular).
	Respiratory Diseases.		Respiratory Diseases.

If then we strike at the root of the "tropical" fevers and bowel complaints we may hope to control the chief sources of loss in the army at all periods of service. We have seen that these primary causes of sickness and mortality are largely due to the influence of first exposure to the alien environment, and the question at once arises : are we able to remove or modify this influence in any effective degree ?

There is little doubt in the writer's mind as to the answer which may be given, an answer which, moreover, has the sanction of practical experience. It cannot be doubted that we should go far to secure the end in view if a selected area in South Africa were adopted as the great depôt and training ground for the European element of the Imperial army for foreign service. With the paramount strategical considerations thus fulfilled, the term of service in India might well be reduced to five years at the outside, no very revolutionary measure, as during the period 1895-1898 only about one-fifth of the total force was composed of men having more than five years' service in the country. Further, as an important complement to a preliminary residence and training in South Africa, it should be possible to extend considerably the occupation of Hill sites in India during the summer and monsoon seasons, with special regard to the interests of new regiments (see Chapters IV. and V.).

The *rationale* of these proposals is based partly on general considerations to be discussed in the following Chapter, and on the experience of the last two years of the record, during which a very large proportion of the force exposed has had previous experience of service in South Africa. As regards Enteric Fever the results have been sufficiently indicated in the discussion of the phenomena of the "period of decline", and it remains to show that the same influence operated to reduce the morbidity from all other causes to a very considerable extent. To this end we may compare the incidence of the sickness and mortality on the different age and service periods during 1896-1903, the whole series of years being divided up to correspond with the different circumstances which marked their course. Thus in 1896-98 we have the forces exposed under fairly normal conditions as regards its age and service constitution; in 1899-1901, the supply of reliefs and drafts was temporarily suspended, the age and service constitution rising to unusual proportions; while in 1902-03 the tide returned with an unexampled influx of nearly 44,000 new arrivals which reinforced the early age and service periods, the later ones also now attaining their highest proportions. The important point to note, in connexion with the results for 1902-03, is that the majority of new arrivals came from South Africa and other Colonial stations,* while at the other end of the scale the strengths are raised to an abnormal extent, by the retention of men in India beyond the usual term. We are now in a position to compare the results of previous experience acquired in India (1899-1901) with that acquired for the most part in South Africa (1902-03).

TABLE No. IX.

Sickness (A) and Mortality (D) from All Causes (excluding Enteric Fever) at the different Ages—1896-1903.

INDIA 1896-1903.		Ratios per mille of strength. Under 20.	20-24.	25-29.	30-34.	35-40.	40 +
1896-98.	A.	1066·8	1709·8	1242·6	631·4	544·5	563·0
	D.	5·23	8·68	8·45	11·76	14·78	31·93
1899-1901. (Previous Experience in India.)	A	958·5	1321·7	1106·6	626·2	436·7	525·0
	D.	4·27	7·04	9 53	11·35	12·12	25·37
1902-03. (Previous Experience in South Africa)	A.	768·2	1223·5	1028·3	743·0	539·5	556·4
	D.	3·21	6·87	11·18	13·59	16·16	23·35

* Of 55 Regiments present in India in 1904, only 16 had arrived direct from England. 29 came from Africa (Egypt, Cape and Natal). 4 from Malta, 2 from Singapore, 2 from Gibraltar and 1 each from Ceylon and Hong Kong.

TABLE NO. IX (*concld.*)

The same for the different periods of Service.

		Under 1 year.	1—2 years.	2—3 years.	3—4 years.	4—5 years.	5—10 years.	10 years +
1896-98.	A.	1695·1	1518·7	1472·9	1332·0	1253·7	1292·1	601·5
	D.	8·56	8·24	8·76	7·45	8·01	13·33	14·58
1899-1901.	A.	1430·5	1276·1	1191·4	1111·9	1021·9	1064·5	523·6
	D.	9·0	7·18	7·98	7·19	6·77	11·31	11·22
1902-03.	A	1125·8	1157·7	961·7	955·2	965·6	1182·9	731·6
	D	9·49	8·11	4·45	6·10	8·73	15·08	10·83

The general significance of these results is scarcely open to question; we cannot distinguish exactly between the influence of previous experience gained in India and South Africa, respectively, as men exposed to one or other environment are included to an uncertain degree in the same age and service periods, but the fall in the rates in 1902-03 is definitely enough associated with the periods which must have been most largely recruited by the men from South Africa. We may obtain confirmatory evidence of the distinct effects of this preliminary experience by comparing the mortality recorded during the first year of Indian service among the corps which came from South Africa with that for the army as a whole under similar conditions in all other respects. In 1903 there were 9 regiments from South Africa which were undergoing their first year's experience of service in India, and among them there were 86 fatalities from all causes, giving a ratio *per mille* of 12·1; but if the deaths from Cholera, in an exceptionally severe outbreak in one corps, be excluded, the rate falls to 9·9.

TABLE No. X.

India, 1903.	Death-rate All Causes.	Death-rate excluding Cholera.
Regiments from South Africa during 1st year of service. ...	12·1	9·9
Army of India, as a whole, but excluding above regiments. ...	13·1	12·5
Army of India, Men having not more than 1 year's service. ...	15·95	15·14

It may be added that the loss by invaliding furnishes additional confirmation by following the same course as the sickness and mortality, in so far that the rates on the earlier age and service periods were greatly reduced in 1902-03, while, on the contrary, those falling on the later periods were exceptionally high.

Let us now glance at the results of residence in South Africa, as exhibited in the returns for that Command during the last five years for which the record is complete, *i.e.*, the period prior to the Boer campaign, and we give the figures for India for the same series of years for comparison :—

TABLE No. XI.

European Troops serving in the South African Command and in India, 1894-1898.

	Ratios per mille of strength.							
	Enteric Fever.		Other continued and Malarial Fevers.		Dysentery.		All Causes.	
	A	D	A	D	A	D	A	D
South Africa ..	20·8	3·08	78·8	·11	22·1	·49	881·2	7·75
India ..	27·2	7·21	393·0	·65	29·0	·83	1461·2	17·13

Finally, it is necessary to show as clearly as possible the effect of residence in the hills on the life and health of the European troops, for this has important bearings not only on the discussion of the etiology to be developed in the next chapter, but also on the preventive and economic aspects of the whole problem. We shall now combine the results for the last nine years for which the records are available, and compare the sickness and mortality rates from the chief causes, and for all causes, including and excluding Enteric Fever, in the Hill Stations proper, and in the Hill Convalescent Depôts, with those for the rest of India (the plains).

TABLE. No. XII.

Comparison of sickness and mortality among European Troops located in Hill Stations, Convalescent Depôts and Plains Stations, India, 1895-1903.

(Ratios per mille of strength exposed.)

	Hill-Stations.		Convalescent Depôts in Hills.		Rest of India: – Plains Stations.	
	Admissions.	Deaths.	Admissions	Deaths.	Admissions	Deaths.
1. Cholera	·3	·22	·2	·14	·9	·67
2. Small-pox ...	·1	·01	·1	...	·6	·07
3. Intermittent fever ...	144·8	·09	284·7	·42	324·6	·38
4. Remittent fever ..	8·1	·18	8·3	·46	15·3	·28
5. Simple continued fever	13·7	...	9·6	·04	31·3	·03
6. Heat Stroke ...	·4	·05	·	·07	4·5	·93
7. Dysentery ...	16·4	·51	21·0	·74	29 8	1·08
8. Hepatitis ..	13·6	·03	23 1	·04	17·0	·05
9. Abscess of liver ...	1·8	1·09	3 7	2·42	2·4	1·40
10. Circulatory diseases..	12·1	·67	18·7	·63	11·9	·61
11. Rheumatic fever .	2·4	·01	1·7	...	·9	·02
12. Pneumonia ..	5·3	·64	4 3	·81	4·3	·59
13. Tubercle of Lungs ...	2·7	·28	4·0	·81	3·9	·55
14. Other Respiratory diseases ...	24·0	·12	30·6	·28	23·8	·13
15. Diarrhœa ...	22·9	·03	22·0	...	19·7	·06
16. Enteric fever ..	29·9	5 95	15·0	3·71	22·7	6·21
All Causes ...	986·7	11·73	1221 7	13·90	1314·7	16·39
All Causes Excluding Enteric	956 8	5·78	1206·7	10 19	1292·0	10·18

Note.—Aggregate strength: 1895—1903.
- Hill Stations 77,754
- Convalescent Depôts .. 28,561
- Plains Stations 491,409

We must leave these figures to convey their own lessons. noting that the comparison should be made between the first and last series, as the returns for convalescent depôts refer chiefly to disease contracted in the plains, as is to a considerable extent, indeed, the case with the hill stations proper, but this only renders the contrast more instructive. As regards the age and service constitution, the strength exposed in the hills is at a disadvantage in regard to the liability to many of the chief causes of sickness and mortality (see later), and beyond this, the period of the year (April to October) to which the returns from the hills mostly refer is precisely that of disproportionately heavy incidence in regard to the chief sources of loss for the army as a whole. But in spite of these facts we see the morbidity amounting to only about three-fourths, and the mortality to little more than one-half, of that suffered by the troops in the plains, when Enteric Fever is excluded. Moreover, the table shows that these remarkable results are almost entirely due to the diminished incidence of the more purely "tropical" diseases (Nos. 1 to 9 in the list, above the dotted line) ; if it can be shown that the Enteric Fever of the hills derives its origin from infection in the plains—see chapter V.—our present contention will be amply substantiated, while important points in the etiology and prevention of the disease will be elucidated.

CHAPTER III.

Etiology.

"*We cannot distinguish logically between principal and minor causes, or between cause and conditions in the case of two or more constituent parts of a cause, each of which is necessary and none of which is, by itself, sufficient.*"

The scope of this Essay does not include a detailed summary of the enormous mass of facts and opinions to which the study of the morphology and biology of the micro-organism, now universally regarded as the causative agent of Enteric Fever, has given rise. There is, indeed, no lack of authoritative guidance through the maze of fact and conjecture which has accumulated about this aspect of the subject during the last twenty years, and what is said here will be confined to the essential results of the work accomplished in their bearing on the practical problem. But it is impossible to avoid some brief discussion of certain fundamental principles, which are frequently overlooked in the laboratory of the bacteriologist, and in the absence of the guidance of which we are destined to be led by our studies into an uncharted and sterile desert of learning, where a little knowledge would be an excellent thing. In the best of the standard works we get too much of the partial view to the obscuration of the whole, and thus first one and then another essential factor in the complex of forces is relied on to explain the resultant, with ultimate inevitable failure. And hence the strife of "Localists" and "Contagionists," hence the exclusive views of the rôle of the specific virus, or of some climatological or local influence, each of which has its day and fails to justify the efforts based thereon.

Life and health depend on the continuous and more or less successful adjustment of the relations of the individual and the race to the environment, and the "quantity" which determines the measure of health of an organism is not its absolute "fitness," but the ratio of its fitness to the strain imposed upon it by its environment, and this ratio can be changed by the variation of either of the factors or of both. No two individuals of a species, whether man or micro-organism, are absolutely identical; there are subtle differences potentially inherent, or actively present, imposed by the influences of race, of heredity and the composition of the tissue cells which involve differences in the reaction to the environment and its manifold stimuli, and to which adaptation must be made. Any change in habits of life, work, diet, etc., must modify chemical and vital function and structure, and so, by selection, will evolve different types and different powers of resistance. "There is no part of the body of an individual, not the most insignificant, which has arisen in any other way than under the influence of the conditions of life; and the parts of the body conform to these conditions as the channel of a river is shaped by the stream that flows in it." (Weismann.) The power of reacting to a certain stimulus in a certain way resides in the predisposition of the organism or the part thereof involved; this pre-disposition is innate, it is an essential factor in the "specificity" of the reaction which we recognize as disease: it is present in different degrees in different races, and varies, probably in some definite relation to the experience of disease, in the course of the progress of each race; and inasmuch as the ontogenetic development is a blurred recapitulation of the phylogenetic, it also varies at different stages of the life of the individual. In brief, the essence of "specific" infectious disease would appear to lie not in the nature of the tissue cell of the host, nor in that of the micro-organism, nor in the circumstances of time and place, taken alone, but that it is the function of the sum of all these factors in interaction. These considerations may appear as abstract biological commonplaces, but, in truth, they have the most intimate practical bearing on the problem before us, and in no other light can the facts to be adduced be made clear. It is not suggested that the application of these principles has been altogether ignored, but they have not been grasped as the essential key to the whole problem, certain parts of which have been referred to this or that biological law, with a prevailing tendency to invoke the purely bacteriological view, in the zeal born of devotion to a new and fascinating branch of science.

The point of view which is taken here will be made clearer by a reference to one or two significant facts in the epidemiology of Enteric Fever, which are within the knowledge of all.

Nothing is more striking than the very special incidence of the disease on certain age periods, and the liability to infection in the earliest periods of Indian service, and herein we have influences which can be shown to be distinct in their operation, although the periods of greatest liability coincide to a large extent. Again, there is the very characteristic local and seasonal prevalence, which has hitherto baffled explanation. Further, nothing is better established, and yet so little recognized, than the marked differences in the reaction displayed by different individuals to the attack of the same "specific" virus. We should all agree in expecting different results in nearly every case from the administration of an equal dose of calomel to a number of individuals under fairly similar circumstances as to age, etc., but we are apt to be misled by aberrations from "type" as based on empirical clinical experience, which must often occur in the reaction to the attack of a pathogenic micro-organism. For example, Brouardel reports a sudden outbreak of Enteric Fever in a small and compact village community, which was traced, with scarce a possibility of doubt, to specific contamination of the common water-supply. Of 24 persons who were probably exposed to infection, 20 were attacked almost simultaneously, but the true nature of many of the cases would not have been recognized, had they not been associated so definitely with the common outbreak. Four of the victims died, six recovered after a "typical" course of the disease ; six others suffered from what Brouardel calls the "*état febrile typhique*" ; two had short attacks of "*embarras gastriques*," apparently not specific, and the remaining two presented the symptoms of simple fever with no apparent organic implications ("Simple Continued Fever"). Brouardel suggests that we ought to be prepared to recognize a mild form of Enteric, which he calls "*typhoidette*," just as we recognize a "varioloid" form of Small-pox ; such cases doubtless confer immunity, and are potent sources of infection.

Now, the foregoing considerations which present, not rare and occasional, but constant and characteristic, features of the epidemiology, point conclusively to a wider conception of the pathological process than would be accounted for by the fortuitous action of a "dose" of virus *per se*, irrespective of time, of place, and of the human organism attacked, and any theory based on such a view must necessarily fail in the solution of the problem, and mislead the efforts directed towards prevention. In the desire to mark down the "cause" in order to attack it and "prevent" it, we are apt to forget that where a phenomenon occurs only under certain conditions, it does not follow that these are the causes thereof. A certain temperature is necessary for the development of the bird in the egg, but the temperature, *per se*, is not the cause of this development. The egg has acquired the power of producing a bird, chiefly as the result of a long phyletic course of development which has led to such a chemical and physical structure in the egg and in the sperm cell (analogy of host and specific virus) that after their union and development a bird, and only a bird of a particular species, is produced (analogy of "specific" disease); but certain conditions are essential for this development, and a definite temperature is one of these conditions (factor of environment, climatic influence). Given the access of a specific virus, under the necessary conditions, it is the physical quality of the tissue cells of the host that determines the pathological result. In this larger view we have, on the one hand, to regard the process of adaptation (the reaction of the organism to external "pathogenic" stimuli) as due to natural selection operating upon the general variability of organisms under different conditions; and, on the other hand, we must recognize the effect of the environment in producing a "disharmony" and defective adjustment, when the conditions of life of an organism are suddenly changed, as by traffic and travel involving the expatriation of men and animals, which have been predominant features of modern civilization since the "age of discovery" and the growth of colonial empires. And these influences have been complicated and enhanced by commerce and contact with alien races, by the rapid and ill-regulated growth of settled urban communities, or by the aggregation of large numbers of men in temporary camp-like settlements.

The discussion of the etiology of the subject in this place will consequently embrace some of the salient considerations affecting:—

(1). The human organism exposed to risk, as the "host" of the parasite, the source, the propagator and disseminator (transporter or vehicle) of infection; and as, probably, the "soil" for its maintenance in the intervals between more or less definite outbreaks of the disease, and for the renewal and development of the pathogenic properties of the parasite. It will be obvious that the "host," on this view, must occupy the predominant rôle in the epidemiological drama.

(2). The pathogenic microbic virus (the "parasite") as represented by the *bacillus typhosus* (Eberth) and allied forms.

(3). The environment, in its physical (including climatic) and also its organic or social aspects, *i.e.*, as it operates through traffic and the aggregation of both human and microbic organisms; thus both (1) and (2) in the aggregate form an essential element in (3). Both human organism and microbe —the host and the parasite—are subject to modification, adaptation, under the influence of the environment; the former, *e.g.*, according to the measure of adjustment, is rendered more or less susceptible or resistant, the latter acquires greater or less powers of infectivity or virulence, and thus the environment operates to influence, but not to determine exclusively, the local and seasonal incidence of disease. And, finally, when taken in its fullest connotation, the environment determines the measure and means of the access of parasite to host, as by *fomites*, water, food, flies, dust, &c., and by transport from place to place by the infected host. This view displays the complete chain in the complex process of infection, and it is essential to bear this scheme in mind in considering the epidemiological facts which will be presented in due course.

It will be necessary, in the first place, to deal, as briefly as possible with the broad, salient features of the environment, not only because they provide the key to certain characteristic phenomena of the local and seasonal incidence of the disease, but also to elucidate the conditions of the drama in which the host and parasite play their parts. India, as a whole, is often regarded as a sea-girt peninsula, but if on a map of Asia a line be drawn across the country continuous with the general southern coast line of the continent, it will pass along the Central Vindhyan hill range, and divide the Dependency into two roughly equal parts: the continental area running east and west, and the peninsula proper extending north to south from the Vindhyan range. The former part is dominated on the north and north-west by the prodigious mass of the Himalayas, between which and the Vindhyas lies the great expanse of the Indo-Gangetic alluvial plain, which rises gradually in the course of 1,550 miles from sea-level in Lower Bengal to an altitude of 1,200—1,600 feet in the extreme north-west (Peshawar). It is intersected by a series of great rivers, and overlies a vast sea of fresh water (the "ground-water"), the distance of which below the surface soil level increases generally with the upward slope of the plain, *i.e.*, from east to north-west. Two other notable physical features are co-ordinated with this trend of the area in question; first, the surface soil (alluvium) passes from a condition of more or less consistent clay and mud in the east, into looser loam in the central parts, and into fine dry sand in the north-west (Punjab). Secondly, the course of the plain is more and more inland the farther north and west we proceed, so that part of the United Provinces and most of the Punjab is thrust wedge-like into the continental mass of Asia.* This "plains" area and the lower spurs of the Himalayan range include the sites of the cantonments occupied by the troops in the Bengal and Punjab Commands, to which a special interest and importance attaches in connexion with the endemic prevalence of Enteric Fever. This is the most densely populated area in India and the richest in agricultural resources, and generally speaking, it includes the main strategic and commercial highways for traffic, along which most of the larger cantonments and rest-camps are located.

Turning now to the south of the Vindhya-Satpura hill ranges, we enter the Peninsula proper in which may be distinguished two markedly contrasted areas, *viz.*, the fringe of the low-lying coast extending along the whole sea line from Karachi on the west to Calcutta in the east, and the central tableland (Deccan) of considerable but varying elevation, which is cut off from the former by lofty hill-ranges which run, in a general way, north and south and parallel to the coast lines. These are the so-called Western and Eastern Ghâts, the former presenting a much higher and more continuous barrier to the meteorological influences arising in the Indian ocean than the latter. For us, the most important of these influences, beyond the comparative proximity of the huge oceanic surface, is the great Monsoon current of rain-laden winds which, from June to September, drives against the western face of the Ghâts, the summits of which it barely surmounts (and then only in greatly diminished force and amount), and thus leaves the sheltered tableland beyond in comparative aridity, while deluging the exposed coast areas with tropical abundance. This peninsular area, as a whole, includes the Bombay and Madras Military Commands; except along the river valleys it is largely

* In all senses, geographical, climatological, political, the expression "India" comprises the whole area of S. Asia over which British influence now extends; the most important climatic influences have their origin beyond the strict border line of British India. (Holditch.)

composed of broken undulating tableland of varying elevation, including a large extent of forest and uncultivated waste. To the north and west the surface soil consists of the Deccan "Trap" overlying the basaltic rock from which it is derived, and which is of the nature of a huge water-retaining sponge; on the eastern and southern side the soil is, for the most part, the decomposition results of the underlying hard schists and gneiss, which are much fissured, and worn into surface hollows in which water is retained. The northern part of the peninsula proper, *i. e.*, the Deccan tableland, is associated with the "continental" area, not only in certain physical and meteorological characters, but also as regards the local prevalence of Enteric fever; and it forms part of the endemic area.

It now remains to give a very brief account of the more important climatological characteristics of these contrasted areas. Looking to what has been said in regard to the position of India in relation to the continent of Asia and to the Indian Ocean, we may distinguish the influences of two broadly contrasted climates, *viz.*, a *Continental* climate marked by the prevalence of land winds, great dryness of atmosphere, extreme diurnal range of temperature and little or no rain; and an *Oceanic* climate, with great uniformity of temperature, more or less frequent and abundant rainfall, great humidity and a comparatively small daily range of the thermometer. The greater part of the country experiences both these climates in alternation, but in varying degree, the former prevailing from December to May (the dry season), and the latter from June to October (the wet or Monsoon period); but the farther north and west we proceed, the more definitely marked and persistent are the continental influences, while throughout the peninsular coast areas, the climate is consistently oceanic at all times. While the meridian altitude of the sun gives Southern India and Burma (in the tropic zone) the warmest climate on the average of the whole year, and we get, here, no "cold season," yet the length of the daily period of the solar action determines the highest and lowest temperatures in the almost rainless area of the North-West (Punjab—"continental" area), and here the contrast between the summer and winter temperatures, as well as the diurnal range, is greatest. The point to be grasped is the fact that scarcely anywhere else on the world's surface, within the limits of an equal area, is a greater climatic contrast to be found than that between southern "oceanic" India and Burma and the "continental" inland country; the one damp, equably warm, equatorial; the other exhibiting annual alternations of extreme heat and cold to below freezing point, with rare and scanty rain. Again, in the cold season of the interior and north, the temperature contrast is between the north and south, the isotherms running east and west, being lowest in the north and gradually rising as we proceed south; but in the hot season the contrast is between the interior and the coasts, the hottest area, as a whole, being the central tableland described above, though the temperature of the northern and north-western plains is but little lower at the same time; and, indeed, this hottest mean is transferred to the north at the culmination of the season in May, when mean daily temperatures of 100°—105° and maxima of 120° are of constant occurrence. In June-July occurs the transformation to the oceanic climate due to the Monsoon rains, which last for three to four months and induce comparatively uniform temperatures over the greater part of the country, but notably in the peninsular area, the mean ranging between 80° and 85°. In the Punjab and the North-West the mean still ranges above 90° at this period, but owing to the infrequency and irregularity of the rainfalls, the temperature is liable to sudden and considerable but temporary depressions following precipitation; these depressions often amount to as much as 10°; they are a characteristic feature of the Upper Indian climate at a season when the mean temperature is high, and they are a potent cause of "chills" with all the consequences involved therein. (This is also the case during the winter months in a large part of the Himalayan submontane area—United Provinces and Punjab—where the winter rainfall, though actually small, is relatively abundant as compared with the almost rainless condition of the rest of the country; and beyond this, there is at this time the influence of the snow storms in the mountains in promoting sudden depressions of temperature.) And it is to be noted that these are superadded to the regular daily fluctuations of temperature, and that they occur for the most part when the body is least able to resist their influence and when the lightest clothing is worn. The greatest daily range of temperature, which never exceeds 10° to 20° in England, varies from 35° to 40° in the Punjab and the North-West, and from 35° to 38° in the central tableland (Deccan), 30° in the United Provinces, 24° to 30° in the interior of Southern

India (peninsula), to 19° on the Coasts. The annual range follows a similar distribution, varying from 80° to 92° in the Punjab, 76° in the United Provinces, 50° to 62° in the Deccan tableland, and from 30° to 48° on the Coasts.

Subject to these main contrasts—of dry and wet Monsoons—we may distinguish four well-marked seasons each covering, practically three months and distributed as follows :—

I. Dry Monsoon, includes
   (1) The Cold weather period (mid-December to mid-March).
   (2) The Hot weather period (mid-March to mid-June).

II. Wet Monsoon, includes
   (3) The South-West Monsoon proper, or period of the general rains (mid-June to mid-September).
   (4) The Retreat of the South-West Monsoon and gradual onset of the dry Monsoon (mid-September to mid-December).

Associated with each of the marked climatic contrasts. cold, hot, and wet seasons, there are from time to time profound disturbances of a more or less occasional but distinctive character, in the form of storms. The cold weather storms (cyclonic) arise in Persia and drift across Baluchistan to the Punjab and the United Provinces, but do not affect the Peninsula south of the Vindhyas. They give snow to the Himalayas and the occasional rain for the wheat and other cold weather crops of the northern (continental) area. The hot weather disturbances appear as dust-storms (with which, however, moisture is incorporated though it rarely appears as rain) in the dry continental region ; in Bengal proper and in Assam, these take the form of ordinary but violent thunderstorms with rain (''Nor'-westers''). The storms of the wet (Monsoon) period give the tropical deluges ; they traverse the country in different tracks according to their origin in the Arabian Sea or in the Bay, and follow a capricious and varying course. Some areas are deluged and others, in close contiguity, are left practically rainless, so that the average annual number of storms is often needed to hit the mark everywhere in a normal season. But this rarely occurs ; the probability that the rainfall will everywhere conform exactly to the average is *nil :* this average is therefore derived from compensatory alternations of drought and deluge over long periods. The areas chiefly affected by aberrations and defect of rainfall are the Deccan tableland, North-West and Central India (including Punjab), and the United Provinces and Eastern Rajputana, which, as we shall see, have a special interest for us as comprising the endemic area of Enteric Fever. "The weather in India is distinguished by massiveness, intensity and persistance of abnormal features, rather than by the frequency and rapid succession of important changes." (Sir J. Eliot.)

Space does not permit of a discussion of the physics and of the physiological effects of the climatological factors which determine the broad contrasts which mark the oceanic and the continental areas respectively. It is, however, necessary to distinguish between radiant or sun heat and shade temperature. The rays of the sun have great power of heating the human body and other solid substances on which they fall, but only slightly affect the air through which they pass. The air would be, indeed, quite diathermic, were it not for the vapour it contains, and the greater the amount of the vapour the less powerful is the direct or radiant sun heat (compare coasts with continental inland areas). The shade temperature is due mainly to the warmth imparted to the air from the ground previously warmed by the sun's rays, though it may be greatly influenced by winds from distant regions, *e.g.*, from the ocean on the one hand or from the desert regions of the continent on the other hand. Vapour on the ground also here plays a most important part in lowering and equalising shade temperature, in preventing radiation and diminishing the daily range, which is at its highest in the dry inland regions under a clear sky. We shall allude later to the effects of the colour and consistence of the soil in this connexion.

High shade temperature is much less easily borne than radiant heat, and, as Parkes has said, it "exerts a depressing influence, lessening the great functions of digestion, respiration, and sanguification, and, directly or indirectly, the metabolism of the tissues." We know little of the effect of the direct rays of tropical sunlight on the human body, but we must conclude that certain of the component rays exercise a stimulant and irritant action on the cutaneous nerve endings and the capillary circulation, which doubtless after continuous exposure results in depression of function and defective adjustment. The subject is an important one as shown by the researches of Finsen and others, and it is desirable that experimental trials should be made of the protection afforded by different coloured linings to the soldiers' clothing, a hint being derived from the integumentary pigment of the native races.

which has probably been developed by selection under the stress of physiological adaptation.

Lastly, we may barely note the extraordinary influence of tropical rainfall in purifying a dust-laden atmosphere, in lowering shade temperature and in influencing all soil processes, including those concerned in promoting vegetable, insect, and micro-organic life.

It is scarcely necessary to describe, in detail, the phenomena of that most interesting and important feature of the meteorology of India—the rainfall; its salient characters are familiar, and some of the chief effects on the climate of the different areas have been indicated in the foregoing account; moreover, precise details as to its seasonal and local distribution will be given in the charts which illustrate the next Chapter. Speaking in general terms, the country is subject annually to a short period of deluge (June to September) and to a longer one of almost total absence of rain, as from October to May inclusive there is frequently no precipitation beyond a few scanty showers at the height of the cold season. But, again, there are the greatest contrasts in the relative intensity of the phenomena in different areas under normal conditions. These, moreover, give place from time to time, to periods of excess or failure of the current, with consequent accentuation of the phenomena in proportion to their duration and the area affected. It is important to remember that a comparatively heavy annual rainfall is precipitated within a very short and definite period; the physical and purely mechanical effects of a series of intermittent deluges under a tropical sun have therefore to be taken into account. The sources of the water-supply are more or less shallow wells, rivers, springs and surface reservoirs ("tanks"), while everywhere all sewage and most of the liquid and solid waste matters are committed to the soil for disposal, either by deposit on the surface or by burial, in shallow "trenches" or, occasionally, in deeper excavations. As far as the military cantonments are concerned the grosser and most dangerous sewage matters are thus disposed of at some considerable distance from the barrack sites (a mile or two), but the character and conservancy of the latrines are defective and the methods of removal to the disposal ground leave much to be desired in respect of completeness and celerity, a subject that will be dealt with later. The effect of heavy and continuous rain, is to wash the accumulated soil impurities into the water-sources and to leave stagnant collections of water on the surface, where drainage is defective. The ground-water, replenished by percolation often too rapid for effective filtration, rises quickly in the wells, until in a few weeks, over large areas, it is within a few feet of the surface which it frequently reaches by the end of the Monsoon. In and around the sites of native communities, and not infrequently in some of the cantonment wells, the water is rendered non-potable by infiltration of sewage-derived salts. Meanwhile the face of the country is transformed from the conditions of an arid brown desert to that of a neglected garden due to the springing of the crops and of every constitutent of the "jungle"; and with this there is a phenomenal increase in all indigenous forms of insect and micro-organic life. In this sketch are visible all the conditions which favour the prevalence of bowel complaints and malarial fevers.

During the eight months following the cessation of the Monsoon in September, the course of events is reversed; the water-supplies and surface collections are gradually depleted, and as the hot season advances many are completely exhausted, not a few of those that persist being reduced to the condition of muddy puddles in the case of reservoirs and wells, and to a stagnant chain of pools in the case of all but the largest rivers and streams. The "ground-water" falls to its lowest level, the soil, baked in a tropical sun, is reduced to an almost impalpable powder which is carried in clouds for long distances by the strong, hot, dry land winds which are a feature of this season, and the fine dust penetrates into the most secluded corners of the best protected dwellings. This dust must be inhaled and ingested in large quantities, directly, or indirectly through the medium of food and drink; at the same time flies abound and continue to be a plague throughout the summer, with, however, some notable intermissions.

One more contrast in the conditions in the Northern (continental) and the Southern (peninsular) areas may be noted in regard to soil moisture and water-supplies. We have seen that the former is dominated by the lofty Himalayan range and thus when drought occurs in Upper India, the many large rivers are fed by the melting snows and they carry down large bodies of water at the hottest season of the year to supply the irrigation channels, and doubtless to reinforce the ground water. The case is very different to the south of the Vindhyas, where the rivers take their rise far below the snow line in the tropics; not only are the ordinary water-sources more depleted, as a rule, under ordinary circumstances in the period preceding the rains, but a failure of these enhances greatly all the effects of the normal drought at this time. The main point is that in the Northern area we have always to regard the effect of the snow "spate" in the rivers and streams at the hottest period of the year.

This brief outline of the general physical conditions to which the young British soldier, island-bred in a temperate zone, is subjected after a rapid sea voyage in a crowded transport, will suffice, at least, to give some idea of the strain on the faculties of physiological adjustment that must be involved.

It is scarcely possible to enter into a detailed account of the more domestic conditions that await the soldier in Cantonments, though some of the more important points in this connexion will receive attention in the discussion of our first factor—the human "host." It may, however, be mentioned that, as a general rule, the barracks are far more widely spread over the area occupied than is the case in Europe; the Cantonment at Mian Mir, where the average strength is about 1,000, is said to extend over a space of 10 sq. miles, but this is certainly exceptional. The buildings are dotted, in more or less regular order directed by the aspect, over the bare plain on which a few trees are interspersed in the more favoured sites; the wells, the usual sources of water-supply, are as a rule numerous and are scattered throughout the area, and provide the supply for various purposes, the best being reserved for drinking. The conservancy of these water sources has in recent years received assiduous attention; they are, for the most part, protected from obvious pollution by their distance from the barracks, by good steining, by more or less impervious coverings and by the provision of pumps. But more primitive methods still persist in some of the stations; the system of distribution in too many cases leaves much to be desired and affords openings to the risk of chance contamination, by dust, by manipulation and the transfer to vessels of various kinds for storage. The processes of boiling (or parboiling) the water and treating it with permanganate of potash, which has been a routine practice in most cantonments for the last eight years at least, has introduced obvious dangers, varying with the care and supervision bestowed and the resources at command; but we shall return to this question at a later stage.

The other most conspicuous objects of the site are the cook-houses and latrines which are associated with each barrack and too often with each other, both by contiguity and by the traffic of men, flies, and dust. Very much has been accomplished in recent years in the reform of the kitchen arrangements; they are provided with improved and adequate equipment and are subject to a definite code of hygienic rules and to more or less supervision. Natives are, as a rule, employed as cooks and waiters, but in a few regiments the work is carried out entirely by the soldiers themselves. The reader must be referred for further details on this subject, and to that of the food-supply generally to the Annual Reports of the Sanitary Commissioner (Government of India) and to those of the Army Medical Department. These reports are replete with references to the difficulties and dangers attending the provision and preparation of food supplies, notably as regards milk, vegetables, fruit and all forms of beverage, to which the soldier has access not only within strict Cantonment limits but also in Regimental Bazaars and native towns and villages, where all measures of hygiene and conservancy are at the best partial and perfunctory, and in most cases woefully neglected. The soldier has been said to live in an oasis of hygienic purity in the midst of a desert of filth; the latter term of reproach it is not our concern to contest, and later on it will be necessary to play the rôle of the "advocatus diaboli" in reference to the former comfortable assumption. But there can be no doubt of the fact that if the effective agent of Enteric Fever is an inevitable and constant associate of fæcal filth, then the risks of infection which the soldier runs in his extra-cantonment sallies and adventures are manifestly greatly increased. Here, indeed, we touch a crucial point in the epidemiological problem; we have filth abounding in the native surroundings of our cantonments, constant access to this filth, direct and indirect, by very intimate traffic and commerce between the two communities, and this commerce consists very largely in the purchase for consumption of articles of food and drink which can scarcely escape "specific" pollution—if it be at all prevalent in native haunts and houses. If we could accept the latter premise as an established fact, the etiological problem would indeed be simplified at the expense of the preventive problem. We shall not prejudge the question at this point; it will be advisable to set forth the evidence on the whole case, and to reserve the summing-up and verdict for a concluding chapter; it is only necessary to emphasize the fact of the important element in the environment which is constituted by the presence of the native population and by the contact, direct and indirect, of the troops therewith.

The subject of the methods of removal and disposal of sewage has been alluded to in passing, and this is a matter of such prime importance in its bearing on the causes and prevention of Enteric Fever that it will be reserved for more detailed discussion in the place where the indications can be applied with greatest force (see Chapter X.). It may, however, be as well to fill in this sketch of the environment with some details extracted from the Report of the Army Medical Department (for 1902, p. 207), which afford a picture of the conditions obtaining in the latrines in Cantonments—conditions which, as we have it on the best and most unbiassed authority, are common to the latrines now in use by "all the British troops in the Punjab Command," that is to say, in all cantonments where the main strength and the flower of the British army in India is located. The occasion of the remarks which follow and which were submitted to Government by the Director-General, was an outbreak of Enteric Fever at Umballa.

"On visiting the latrines of the 12th Royal Lancers at this place the conditions found by Major Weir, the Sanitary Officer, were as follows. The description of one latrine applies alike to all. They were visited about 4 P. M., and on entering the latrine of No. 9 barrack room, most of the receptacles were half or quite full of excreta and paper, and flies which were very numerous, covered the receptacles and seats. Two soldiers were using the latrine at the time. One man remained in the latrine for 11 minutes, and the other for 17 minutes. He inquired of one of them if the flies were generally so numerous as they were that evening and was informed that since the regiment came to India, it had always been the same, and that generally about 10 o'clock in the morning the flies were so bad that the men could not go into the latrines. This soldier had several flies walking on his face, and his legs were covered with them. Major Weir walked with him as far as his barrack room, and by the time they reached it, he still had many flies on his clothes. On returning to the latrines a similar condition of affairs was found along the whole line, the seats were soiled with particles of dried excreta, conveyed by the legs of the flies from the open receptacles. There was an interval of 3 or 4 inches between the rim of the earthenware receptacles and the under surface of the seat, so that on many occasions soiling of the platform must inevitably have taken place. To increase the height of the seats, the men had pulled them out of the sliding slots in which they were fixed, and had placed them loosely on the upper surface of the slots. It may be said that after using a latrine a soldier is supposed to cover up the excreta in the pan with a scoopful of dry earth, kept in boxes for that purpose at each seat. As a result of numerous inspections of latrines in every station in the Punjab, Major Weir asserts that the soldier practically never uses the dry earth. The contents of the pans are therefore fully exposed to the attacks of flies." (The handling of the earth-scoops by different men and by sweepers in common is surely objectionable.) "He visited all the latrines of the 12th Lancers on the same evening, and in all the same conditions existed and the same plague of flies. In the majority of the latrines, the sweeper, who is supposed to be present behind the screen, was absent. This man is intended to empty and clean the pan as soon as it has been used. The latrines of the Royal Artillery lines were visited on the same evening. There were few flies, and the seats were cleaner than those in the latrines of the Lancers. Immediately after visiting these regimental latrines he visited those of the Station Hospital to compare their respective conditions. There were few flies in either of these latrines, and the seats were quite clean, whereas on the morning of the same day the condition of the native latrine in the Station Hospital compound was by no means a pattern of cleanliness, and there were many flies in and about it. Next morning at 10-30 A.M. Lieutenant-Colonel Maclean, R.A.M.C, visited the Lancers' latrine, and though there was a strong wind blowing (latrine paper was seen blowing out of a pan), the flies were nearly as numerous as on the evening before. The same state of affairs was found in the latrines which were being used by the wing of the 2nd Royal Highlanders. Of the remaining latrines which were not in use, some had been used and several receptacles remained unemptied. The Crowley carts, which were used to carry the excreta to the trenching grounds, were kept just beside the latrines, the bullocks that draw the carts were tethered near them. In the Umballa latrines these animals live in a house which forms part of a latrine, along with the sweepers, who make the dung of bullocks into fuel cakes. Collections of dung near latrines are great mistake, as both these commodities are the most favourite place for flies in which to deposit their ova. Major Weir states that in his opinion the cause of the outbreak of enteric fever was due to latrine infection, and the active agents in its spread were flies and dried excreta. Granted that one of the latrines, whose condition has been described, becomes infected with the contagium of specific excreta, these conditions are quite sufficient to explain the spread of the disease. It is worth while mentioning that though the married quarters also have latrines, yet on visiting them there were few flies. The cause is that these latrines are but little used, as most of the married families used commodes in their bathrooms. This point may also explain their immunity from attack by the disease. Reference to the numbers which were furnished by men in each barrack-room, lends support to this theory of the spread of the disease. The latrines of all the British troops in the Punjab are essentially the same as those described above, and the method of removal is equally bad. Under the conditions which at present exist, when once a latrine becomes infected, and who can doubt that this is a matter of at least weekly occurrence in some cantonment, everything about the latrine is favourable to the spread of the disease."

No comment will be made at this stage as to the conditions here disclosed nor on their vital significance in regard to the main subject. It need only be added that the methods of removal of excreta are equally bad, as, indeed, this Report affirms. The filth is first removed from the latrine pans to be stored for hours in iron receptacles, and from these it is dumped at uncertain intervals into the carts which are dragged across the cantonment site to the trenching grounds with the constant risk of the spilling of the contents. It is impossible to sterilize the carts and other vessels employed in the multiple stages of this primitive process, and in the hot and wet seasons of the year a swarm of flies escorts the unsavoury vehicles in their passage to and fro ; in the intervals, the carts are kept in the neighbourhood of the latrines, that is to say in proximity to places to which the men constantly resort. No other aspect of cantonment sanitation has been the subject of so much discussion, save perhaps that of the water-supply ; as regards its minor details it has been the battledore and shuttlecock of constant controversy and the sport of patentees ; but the difficulties and the risks of the system are obvious, and at the best they could only be minimised, though never obviated, by the most scrupulous and intelligent care and supervision on the part of all concerned. In the nature of men and things this is too often lacking, and thus we have a system than which no other that could be devised would afford greater facilities for the propagation of infection when once introduced. In fact, in some respects the very efforts put forth are a source of danger ; the root of the problem, the first essential of safety, has been left untouched while effort has been dissipated in endeavours to cut at and control the surface growth of manifold details which are the fruit of a noxious weed so assiduously cultivated.

This brief sketch should suffice to bring before the mind's eye some of the salient features that mark the environment of the soldier in India as contrasted with that of a typical civil urban community in Great Britain ; this remark has indeed the sound of the superfluous, but to grasp the fact is to clear away much of the confusion that too frequently militates against an appreciation of the epidemiological problem, which is so often discussed in terms of European experience. We shall deal immediately with the contrast in the human material exposed, but here we must emphasize the special conditions that characterize cantonment life in India which must affect radically the incidence of any infectious disease ; and these conditions are those which are always associated, in greater or less degree, with what we may refer to as life in military camps. These are certainly not seen in their fullest force in well-ordered cantonments, but in certain essentials they exist in every cantonment to influence the epidemiology. Briefly, we have aggregation in common dormitories and barrack-rooms and refectories ; food-supplies very largely in common, but subject as elsewhere to individual caprice ; water-supplies from (as a rule), numerous detached sources, but any of which may be at the disposal of occasional visitors from another part of the cantonment ; latrines and urinals, numerous and detached, which are the common resort of large numbers daily, but which are also open to occasional use by men from other barracks than those for which they are provided ; methods of conservancy (latrines and surface soil disposal) that must involve contact of the person, direct or indirect, with the most dangerous excreta, which are constantly specifically polluted and always liable to such pollution. On the other hand in civil life, we have the segregation of the individual or the family in a separate dwelling, with, for the most part, very little personal contact with others, save on the highways of traffic or in places of entertainment or of worship ; strangers do not eat or sleep in common rooms, but while the services for water supply and of drainage and sewerage are, on the contrary, common to all, these are so adjusted to individual needs and so conserved, as to minimise the risk of contamination of the one by the other. Moreover the system of immediate removal of the excreta by water-carriage, and the segregation of water-closets preclude the risk of personal contact with infected filth. Thus when Enteric Fever does occur it is seen mainly in widely detached cases or strictly confined to house-outbreaks, and then occasionally in wide-spread explosive epidemics having all the characters of infection from a common source (water-supply).

We pass to the consideration of some of the essential points which bear upon the rôle of the human host as an etiological factor, a complex function which has been briefly summarized on a previous page.

At the conclusion of the preceding chapter, tables were given to show the incidence of, and liability to, Enteric Fever at the different age and Indian service periods of the army as a whole. It was seen that not only is there a very definite contrast in the incidence and liability at the different periods, but also that, with a decided change in the age and service constitution of the forces, there are alterations in the respective morbidity rates and consequently in the liability (which merely expresses the relative proportions of the former). These alterations are important, but while giving full weight to them they do not materially affect the broad indication of the excessive susceptibility to the disease exhibited by the men under 25 years of age and within the first year or two of service. Fully three-fourths (78 *per cent.*) of the cases are recorded as occurring among men at the age of 25 years and under, and two-thirds (64 *per cent.*) among those having less than 2 years service in India. It may be said roughly, but fairly for all

TABLE XIII.

Morbidity and Mortality from Enteric Fever in relation to Age and length of service in India.

		Age.					
		Under 20 yrs.	20-25	25-30	30-35	35-40	40 + —
INDIA British Troops 1895-1898.	Admissions per 1,000	25·6	40·4	15·9	6·8	2·3	0·6
	Liability	27·9	44·1	17·4	7·4	2·5	0·7
	Deaths per 1,000 ...	5·12	10·87	4·09	2·61	1·26	...
	Liability	21·4	45·4	17·1	10·9	5·3	...
ENGLAND & WALES Civil population (Males 1895-98)	Deaths per 1,000	0·267	0·338	0·291		0·223	

Service in India.

		YEARS.						
		Under 1 yr.	1-2	2-3	3-4	4-5	5 10	10 +
INDIA, 1895-1898	Admissions per 1,000.	65·7	32·2	22·7	17·1	15·0	10·2	1·7
	Liability ...	39·9	19·6	13·8	10·4	9·1	6·2	1·0
	Deaths per 1,000.	15·92	8 92	6·15	5·27	4·67	2·92	0·66
	Liability ...	35·8	20·0	13·8	11·8	10·5	6·6	1·5

NOTE.—The period, 1895-1898, is taken to show the rates and liability under ordinary conditions, and to avoid the disturbing effects in subsequent years of the absence of new arrivals during the Boer War.

practical purposes, that the soldier in India up to the end of the 24th year of his age is about 3 times as liable to contract the disease as one between the ages of 25 and 35 years, and the risk of infection during the first year of Indian service is considerably more than twice as great as that incurred in the second year. If the risks of the first two years of service are combined, and contrasted with those of the third and fourth years, the former are seen to exceed the latter in the ratio of nearly 3 to 1. A study of Table No. XIII., page 74, will render the facts clearer, the death-rates for the civil population of England and Wales being included for comparison. The greater liability to death to which the higher age-periods are subject in India, as compared with the liability to attack at the same ages, is only what is to be expected from the higher case mortality of men at these ages.

It is now desirable to subject the main facts as given above to a further analysis in order to emphasize their significance. The following statements give (1) the relative proportions of the strength at each period to the total strength, and (2) of the admissions and deaths at each period to the total morbidity and mortality, and lastly, what may be called the "Relative Liability" at each period, which is calculated by dividing the data under (2) by those under (1).

TABLE XIV.

Proportional incidence of, and Liability to, Enteric Fever by Age—1895—98.

AGE.	*Per cent.* of strength to total strength.	*Per cent.* of Admissions to total.	*Per cent.* of Deaths to total.	Relative Liability to	
				Morbidity.	Mortality.
Under 20 years ...	2·99	2·74	2·05	·92	·69
20 — 25 „ ...	52·18	75·46	75·94	1·45	1·46
25 — 30 „ ...	35·03	19·80	19·19	·57	·55
30 — 35 „ ...	7·05	1·71	2·46	·24	·35
35 — 40 „ ..	2·13	·18	·35	·08	·16
40 and upwards .	·61	·01	......	·02	......

The same for Service in India.

SERVICE.	*Per cent.* of strength to total strength.	*Per cent.* of Admissions to total.	*Per cent.* of Deaths to total.	Relative Liability to	
				Morbidity.	Mortality.
Under 1 year	18·65	42·68	38·68	2·29	2·07
1 — 2 years	18·85	21·14	21·91	1·12	1·16
2 — 3 ..	18·22	14·43	14·61	·79	·80
3 — 4	16·39	9·74	11·27	·59	·59
4 — 5	12·76	6·65	7·77	·52	·61
5 — 10	15·12	5·37	5·76	·36	·38

NOTE.—The figures showing the Relative Liability may be read as whole numbers, *i.e.*, 2·29 = 229. &c. This statement should be studied in the light of the facts disclosed by Table XV, which although it embodies the results of only one year's experience is typical of the Age and Service incidence.

In these results we have to recognize the operation of two distinct influences; *viz.*, that of age and that of varying experience of the environment. This has been a source of confusion to commentators, and what we require in the returns is a statement which will show the distribution of the strength at each age-period according to length of service together with the incidence of Enteric Fever on each category. In the absence of such a statement we must turn to the Relative Liability figures, and further endeavour to appraise the relative value of the two factors by indirect methods; and the remarks which follow will be rendered clearer by a study of the accompanying charts.

A full discussion of the influence of Age would lead us into biological speculations which have but a remote bearing on the practical problem, and we shall, therefore, merely indicate a few of the more important considerations in this connexion. It is well recognized that the army in India pays an exceptionally heavy tribute to the disease on account of its special age-constitution, which is in marked contrast to that of the civil population from which it is drawn. The measure of the excessive liability on this account will be obtained by adjusting the age-distribution of the forces exposed, to the standard of the civil population at home, based on the census records of 1891 and 1901. The details of the calculation need not be given, but when the adjustment is applied to the data for the period 1895-98, it will be found that the total number of cases of Enteric Fever in the army in India would fall from 7,290 to 4,858 on the same strength, if the proportion of men at

TABLE XV.

ENTERIC FEVER, EUROPEAN TROOPS, 1903, BY AGE AND SERVICE IN INDIA.

Age	1st Month.	2nd Month.	3rd Month.	4th Month.	5th Month.	6th Month.	7th Month.	8th Month.	9th Month.	10th Month.	11th Month.	12th Month.	13th Month.	14th Month.	15th Month.	16th Month.	17th Month.	18th Month.	19th Month.	20th Month.	21st Month.	22nd Month.	23rd Month.	24th Month.	25th Month.	26th Month.	27th Month.	28th Month.	29th Month.	30th Month.	31st Month.	32nd Month.	33rd Month.	34th Month.	35th Month.	36th Month.	4th Year.	5th Year.	6th Year.	7th Year.	8th Year.	9th Year.	10th Year.	Over 10 years.	Not classified.	Total.	Ages.	R. per mille.
14	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...	1	14	
15	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...	...	2	15	Str., 3,104 32·2
16	1	...	...	1	2	...	...	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...		...	...	...	...	...	...	...	...	...	...		...	...	...	...	...	...	...	...		...	7	16	
17	...	1	2	3	1	1	1	1	1	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	12	17	
18	...	...	1	1	2	1		1	2	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...		...	...	...	...		...	12	18	
19	3	...	1	1	2	1	...	...	...	...	...	1	2	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...			...		1	15	19	
20	21	22	13	14	15	12	7	4	7	7	3	2	2	...	5	2	...	1	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...					...	140	20	Str., 32,020 30·7
21	19	39	12	14	22	32	16	12	10	12	8	8	6	2	2	...	7	3	2	2	...	1	1	1	...	...	...	...	...	...	1	...	...	...	1	1	1	...	...		...	...		...	5	240	21	
22	17	19	17	17	15	31	10	21	18	12	8	14	11	4	6	3	2	9	3	3	4	6	3	1	2	...	...	2	...	1	...	4	...	2	2	1	4	2	...	...	...	...			2	276	22	
23	15	13	7	10	6	11	4	8	5	9	8	8	6	4	5	6	7	5	1	5	7	2	1	3	3	1	5	1	1	2	1	1	2	1	2	...	5	3		...		...				184	23	
24	4	8	8	7	2	9	8	3	6	2	1	3	3	3	1	1	5	3	1	1	3	2	...	1	2	3	2	4	...	2	...	...	...	3	1	2	13	24	4		1			...		146	24	
25	3	3	3	2	6	3	1	1	2	1	4	2	5	4	1	1	2	1	...	1	...	2	...	...	...	1	1	3	1		...	1	1	...	...	...	9	20	10	3	1		...	...	...	99	26	Str., 22,893 12·1
26	1	5	2	2	3	4	1	2	...	2	2	3	...	1	2	...	...	...	1	...	...	...	3	1	...	...	1	1	1	...	...	...	...	...	...	...	...	13	13	7	1	1	...	1	...	74	26	
27	1	2	...	...	...	...	...	...	...	2	...	...	2	...	...	...	...	...	...	...	...	2	1	...	...	...	...	...	...	...	...	1	...	...	...	...	2	8	7	9	2					39	27	
28	...	1	1	1	...	1	...	...	...	...	1	...	...	1	...	1	...	...	...	...	...	...	1	...	...	...	1		...	...	...	...	...	...	...	...	3	3	8	3	2	1		...	...	29	28	
29	1	...	1	...	1	1	...	1	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	1	1	1	...	...	...	...	...	...	...	...	...	1	2	4	5	6	7	3	...	1	38	29	
30	...	...	...	2	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		2	3	...	1	2	2	2	...	15	30	Str., 6,905 5·9
31	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	1		2		1			1		6	31	
32	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		1		...	2	2	...			7	32	
33	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		2		3	1	2		9	33	
34	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...			...	...		...	2		4	34	
35	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		1					...		1	...	2	36	1,865 3·7
36	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	...	...	...	...	...	...	...	...	...		1		...	...		1		...	...	2	36	
37	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...	1	...		...	...	...	2	...	3	37	
42	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		...							1	...	1	42	Str., 405 R. per mille, 2·4
Not classed	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...								...	3	3		
Total ...	87	115	68	76	79	107	48	56	52	47	35	43	37	21	22	15	23	23	8	12	17	18	10	7	8	6	11	11	3	5	2	7	3	7	6	4	43	79	52	29	17	17	6	12	12	1,366		
	1st 6 months=632						1st year=813						2nd year=213												3rd year = 73												43	79	62	29	17	17	6	12				
	Av. strength, 18,625 R. per mille, 43·6												Str., 10,238 R. per mille, 20·8												Str., 7,940 R. per mille, 9·2												Str., 6,233 8·9	7,987 9·8	Str., 11,901 10·1				Str., 3,268 3·6					

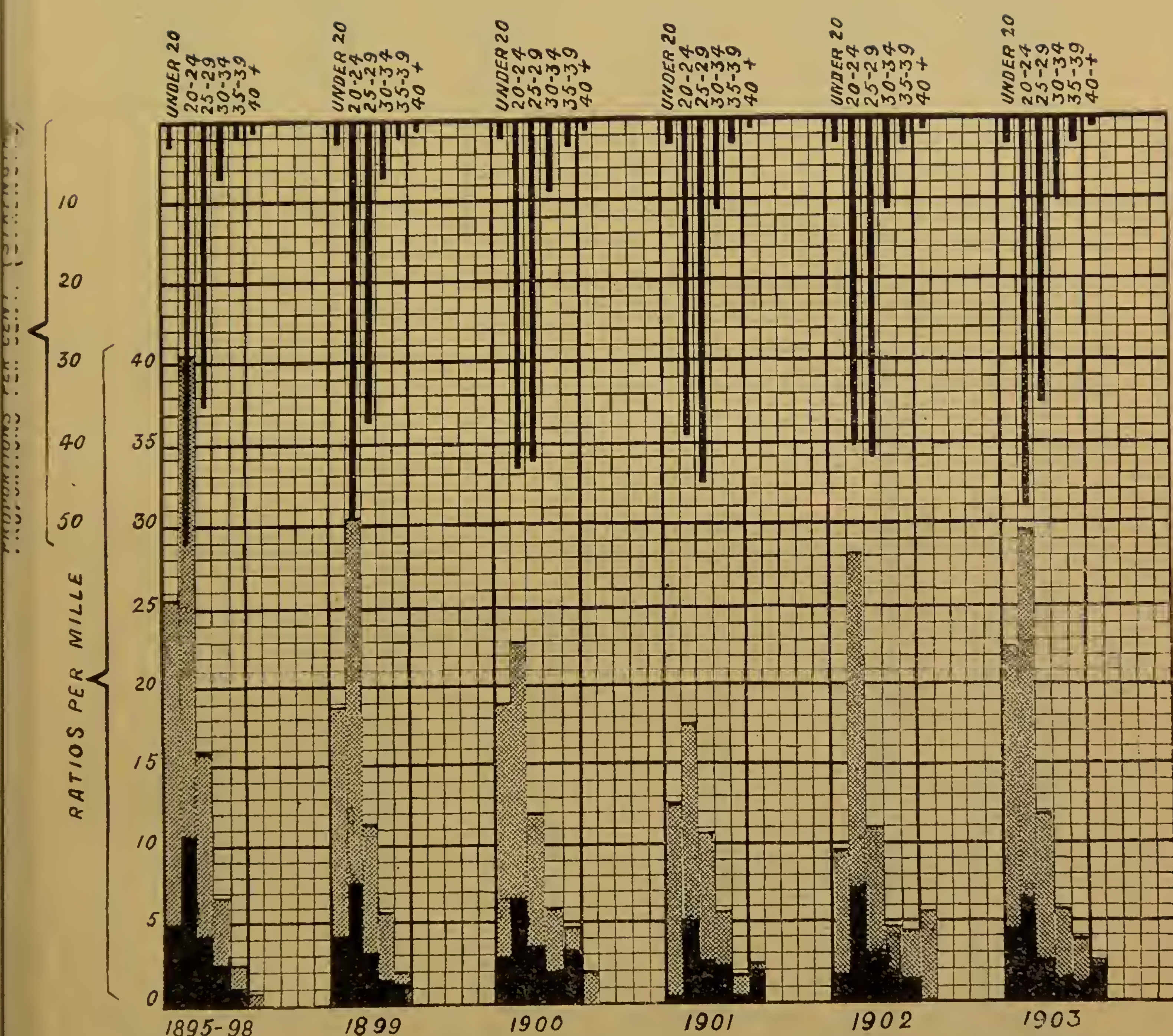


CHART NO. IV.—Enteric Fever at the different Age Periods.
Cross shading = Admissions per 1,000.
Black = Deaths " "
Vertical lines descending from above show proportion per cent. of Strength at each period.

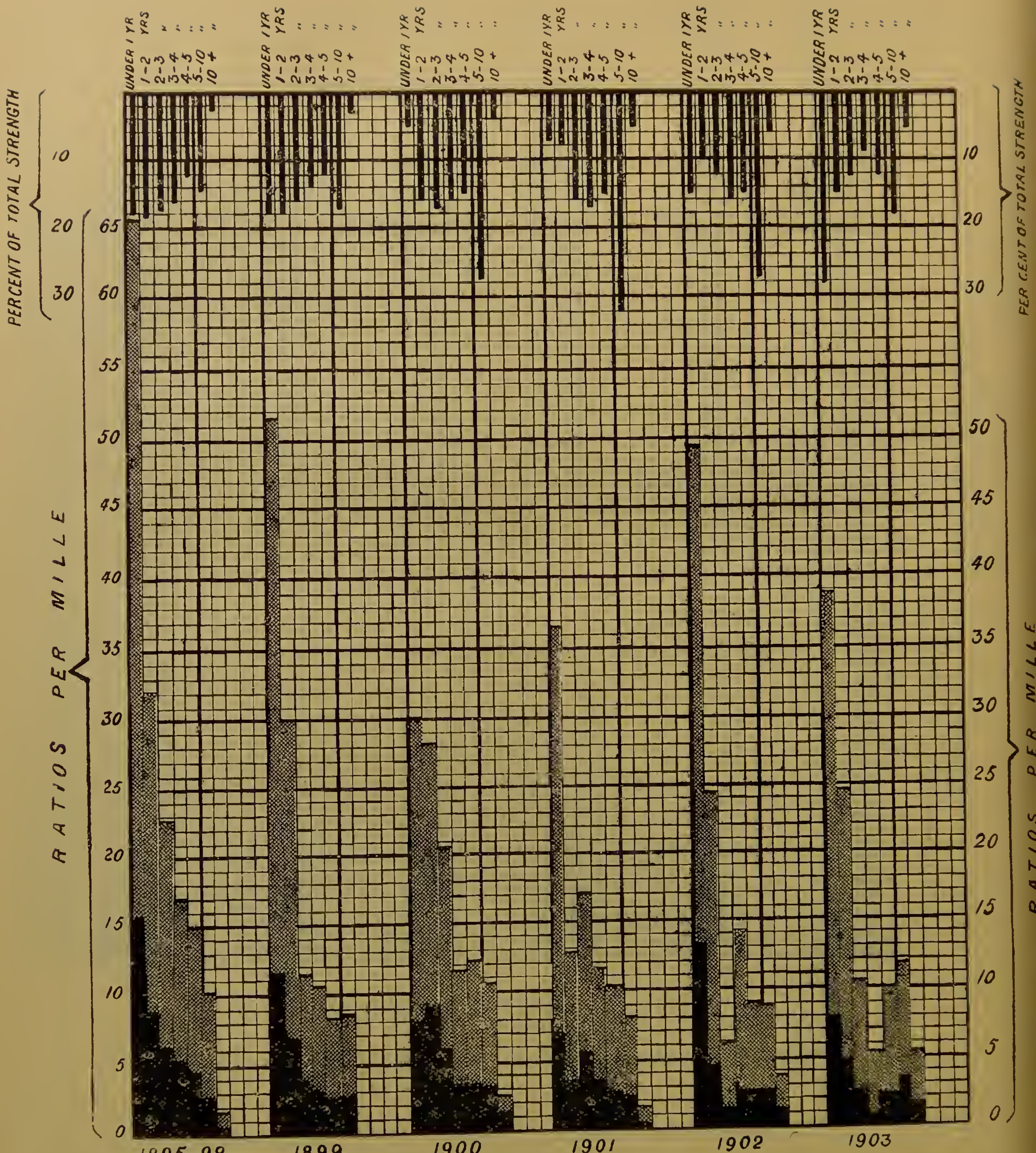


CHART No. V.—Enteric Fever at the different Service Periods.
Cross shading = Admissions per 1,000.
Black = Deaths ,, ,,
Vertical lines descending from above show proportion per cent. of Strength at each period.

each age-period were the same as that which obtained in England and Wales among the male population living at the ages of from 15 to 45 years. Consequently the recorded rate of 27·9 *per mille* under the actual conditions would fall to one of 18·6, the difference, 33 *per cent.*, must therefore be ascribed to the greater risks of the conditions of army service in India. It is of course not intended to imply that if the army in India had been exposed to the conditions of its native habitat during the period in question, it would have suffered at the rate of 18·6 *per mille;* the returns for the army located in the United Kingdom in 1895—98, show that the mean admission rate was only 1·3, and this again has to be discounted by the excessive liability of the age-constitution over that of the general civil population. It will make the position clear if we give a comparison of the rates and the relative liability to which the different populations are subject, respectively :—

TABLE XVI.

Morbidity and Mortality expressed in rates per Million.

AGES.	England and Wales. Civil popn., Males, 15-45 yrs			Army in India.		
	Cases.	Deaths.	Liability to death.	Cases.	Deaths.	Liability to death
15 – 19 ...	1,950	267	23·8	25,600	5,120	21·4
20 — 24 ...	2,200	338	30·2	40,400	10,870	45·4
25 — 34 ...	1,440	291	26·0	14,350	3,840	28 0
35 – 45 ...	903	223	20·0	1,950	979	5·3

It should be noted that the *morbidity* rates for England and Wales are purely an approximate estimate in each case, based on the mortality rates and the case-mortality returns, the hospital statistics being taken and a reduction being made for their exceptional severity. The general course of the incidence on the different age-periods in India exhibits nothing foreign to universal experience elsewhere, save only in the relative extent of the liability, and this must be attributed, in great part, to the operation of the second factor,—experience of the environment (service), but in part also to the fact that in one case we have a more or less static population exposed, in the other, one in which the *personnel* is constantly subject to change. In the army in India all the men do not pass through all the age-periods; many who arrive at the age of under 20 leave in the second or third age-period; many arrive for the first time while nearing the end of the second, or actually in third age-period. These facts make the peculiar relations of the mortality rates for the first and third age-periods in the two populations (army and civil) the more striking in the contrast presented; the death-rate at 25—30 years in England is higher than that under 20, in spite of the conditions of a static population which should ensure the completer effects of the elimination of the most susceptible (most liable to die) in the two earlier periods. The same remark applies to the relatively much higher incidence on the fourth period in England as compared with India, and when the excessive liability of the second age-period in India is taken into account, we must infer that the one result is a corollary of the other; excessive elimination at one period connotes a relatively lower incidence on later periods. The curve of incidence is far more uniform in the one case than in the other, pointing to factors enhancing the susceptibility of soldiers at the age of greatest liability, at which age the majority arrive (effect of first experience of the environment), and then, later, to an extraordinary acquisition of relative immunity due to excessive elimination of the most susceptible or to adjustment involving increased resistance, or to both.

The record for England and Wales would appear to indicate that *the susceptibility to the disease increases with age up to the 25th year and that, thereafter, it is maintained at a fairly constant level for the next 20 years*, having regard to the fact that the population at each succeeding age-period (after 25 years) derives advantage from the previous elimination of susceptible subjects. This opens up some interesting speculations into which we cannot enter: we may note that the great majority of individuals are immune from attack even under the most unfavourable conditions; that susceptibility appears to increase up to the average age of marriage and to be maintained through adult life to middle age: that Enteric Fever may be ranged, as regards age-incidence, with pulmonary tuberculosis, typhus fever, influenza and plague, and more remotely with cancer, in contrast with measles, small-pox, scarlet fever, diphtheria, diarrhœa and malaria among populations having long experience of these affections; and that the liability to other fatal diseases at the

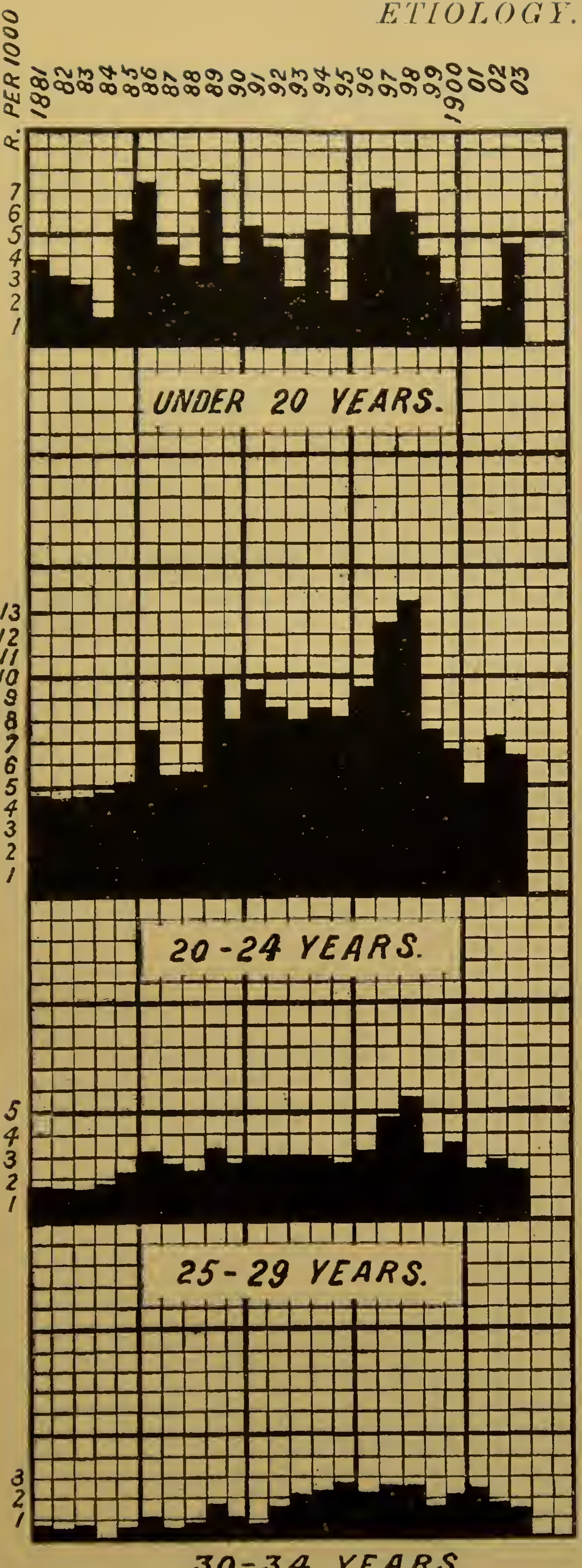


CHART NO. VI.—Enteric Fever Mortality.
Ratios per mille at different age periods, 1881—1903.

different age-periods will affect the relative incidence of Enteric Fever thereon. All these considerations bear upon the important question of the evolution of the race under the influence of disease which, as Archdall Reid has pointed out, must ordinarily proceed in direct proportion to experience, and which is largely determined by the stage of the civilization together with the broad characters of the environment as affecting both the human host and the disease agent. And thus we should expect to find contrasts in the prevalence of, and susceptibility to, the same diseases among different races, and at different stages of the evolution of the same race. The same holds good for the individual, depending on innate qualities derived from the racial experience and on the subsequent reaction to the environment, with the consequent variation in the susceptibility of the different tissues in adaptation to altered conditions of life,—food, work, shelter, aggregation, migration, &c., as well as to experience of disease.

In passing on, we would call attention to the graphic charts which exhibit the characteristic features of the incidence on the different age and service periods for a long series of years under varying conditions. These latter have been discussed in the concluding pages of Chapter II, and we shall avoid the necessity of repetition if the charts are referred to whenever the subject is mentioned in this essay. It will be observed from Chart No. VI., p. 81, that there is a remarkable coincidence in the most characteristic features of the course of the mortality at the different ages during the last quarter of a century; a definite rise or fall in the rates in any year is stamped upon all the age-periods in greater or less degree. That is to say, that all ages are simultaneously affected to a certain degree by increase or decrease of prevalence in any one year and this, of course, would tend to point to sources of infection within the community, as men at all ages are aggregated in cantonments under common conditions, but, from their different habits, they are not all equally exposed to contact with the native environment beyond cantonment limits. We may add as a contribution to the discussion on the effective diagnosis of Enteric Fever that the age incidence of the mortality from other fevers (Remittent, Simple Continued and Malarial) and from Dysentery does not conform to that of the former, beyond a certain resemblance notable in the earlier years in the case of the fevers.

TABLE XVII.

Death-rates from non-Enteric Fevers by Ages.

Periods.	Ratios per mille of strength.			
	Under 20 years.	20-25.	25-30.	30-35.
1881—85 ...	·12	·79	·71	·47
1886—90 ...	·32	·86	·87	·50
1891—95 ...	...	·86	·70	·74
1896—1903 ...	·137	·57	·53	·71

The same for Dysentery.

1881—85 ...	·46	·84	·94	·96
1886—90 ...	·56	·84	·91	·73
1891—95 .	·10	·66	·64	·44
1896—1903 ...	·75	·85	·77	·80

It is, however, noteworthy that if the course of the rates for individual years is followed, a direct relation can be traced between the Enteric mortality and that from the other fevers and from Dysentery and Diarrhœa; that is to say, that when there is a rise or fall in the Enteric death-rate *over or under that of the previous year*, the mortality rates from the other fevers and from the bowel complaints follow suit. They also rise or fall synchronously, but not in the same proportion; but, as the charts and tables show, while the *general tendency* of the Enteric rates is to rise, that of the other fevers and bowel complaints is to decline

The reader must be referred to Chapter II. for a discussion of the phenomenon of variation in age-liability, which has an important bearing on the question just raised as to any real diminution of susceptibility with increasing age up to middle life, and, further, on the influence of acquired immunity, whether by previous attack or by exposure to the environment with which we are about to deal. A recent writer has urged the importance of observing any unusual prevalence in the older age groups in order to ascertain whether it has any relation to any abnormal incidence on the younger men, and whether this diminution of immunity is associated with second attacks among the older men, or whether it is the result of first attacks among the older men who have previously been exposed to infection and escaped (Simpson, *Journ. R.A.M.C.*, April, 1905).

We may now pass to the consideration of the second influence, *viz.*, that of varying experience of the environment. It has been affirmed that we cannot distinguish between the influences of age and early service, and that if men were not sent to India until they had attained the age of 25 years we should practically abolish Enteric Fever from the army. But this contention cannot be sustained; it is true that the rates become comparatively very low in all subsequent age periods, but this is due, in very large measure, to the fact that the most susceptible subjects have been eliminated by attack, whether recognized or not, in the earlier years of Indian service. It is a little difficult to prove this by an appeal to recent statistics, because the returns do not give the strengths of the men at the different age-periods according to length of service. Fortunately the subject interested the late Dr. Bryden (the first Statistical Officer to the Government of India), and in his Report on the Vital Statistics of the European army in

Bengal for 1871-75, he was able to give an analysis of the mortality at the different ages of the newly-arrived regiments during the first two years of their service. This shows that for the men up to the age of 25, the death-rate from Enteric Fever was 9·77 *per mille* and from other Remittent and Continued Fevers, 2·10, or taken together (to avoid any error from inadequate diagnosis in those days), a total fever mortality of 11·87. But the men of the same units at the age of 25 to 30 years, exposed simultaneously to similar risks, died from Enteric at the rate of 10·16 *per mille*, and from "other fevers" at the rate of 3·84, giving a total "fever" mortality of 14·0, an excess of over 2 *per mille* as compared with the earlier age-period. If due allowance be made for the higher case mortality of older men, there is ample margin for the indication of a very similar rate of liability in the two bodies of men at different ages up to 30 years of age, and this must be largely attributed to the influence of the environment during the first two years of exposure thereto. This is confirmed by evidence, direct and indirect, and by considerations which may be said to have a weighty measure of probability in their favour. For instance, it is found that among the new regiments having not more than two years' service in 1902, the admission and death-rates from Enteric were 25·4 and 6·24 *per mille* respectively, against ratios of 26·8 and 6·6 for the men in the army as a whole whose age did not exceed 25 years. The incidence is practically identical, but the age composition of the new regiments in 1902 must have been considerably higher than that of the rest of the army, as nearly one-half of the former came to India after a term of duty in South Africa or in the other Colonies, where also many of their susceptible individuals had been eliminated from further liability to attacks of the disease.

The same results are apparent in the history of the new regiments in 1903, the strength of those not having more than two years' service being altogether 21,281, and of this number no less than 16,568 came from South Africa. The rates recorded on account of Enteric Fever were 28·0 and 5·03 per mille, as compared with 29·3 and 6·2 respectively, among the men under 25 years of age in the rest of the army.

These deductions are, it is true, not conclusive, but we need not depend further on calculations having merely the value of high probability which it would be wearisome to set forth. That there is, indeed, some distinct and potent influence operating to enhance the liability to the disease at the age when the great majority of the men arrive in India, beyond that which is experienced in Europe, is demonstrated by a study of the Relative Liability rates (see Table XIV). These exhibit the relations borne by the proportional incidence of the disease at each age and service period to the proportions of the strength included in each period. And if the Relative Liability "under one year of service" (229) be compared with that for the 20-25 year age group (145) we get a measure of the force of the influence of first exposure to the environment, for it must be remembered that included in the former group is an uncertain number of men at the less susceptible ages. It is further noteworthy that the Relative Liability rate at over three and up to 10 years' service, 0·5, to be taken as 50, agrees approximately with that for the age-period, 25-35, which is precisely what might be expected. The large Table XV. shows that in 1903, while there were 986 attacks in a strength of 32,020 at the ages 20-24, (30·7 *per mille*) there were 813 cases in a strength of 18,625 during the first 12 months of service, (43·6 *per mille*). This far heavier incidence on the earliest service period, could not occur if age *per se* were the predominant predisposing factor, for a considerable number of men at the less susceptible age periods are included in the strength exposed during the first year, for the table also shows that no less than 26 *per cent.* of the attacks among the 23,000 men at the age of 25-30 occurred during the first 12 months.

These considerations are reinforced by an analysis of the facts of the incidence of the disease on the early age and service periods under contrasted conditions of age and service constitution as already shown in the concluding remarks of Chapter II. (*q.v.*). The position may be demonstrated from another aspect. Let us compare the incidence on the men under 25 years of age and under two years of Indian service during 1897-98 when the proportions in these categories were high, with that during the triennium of 1900-01-02 when the proportions of young and newly-arrived men were exceptionally low; we may combine the results from six plains stations in the endemic area and from eight of the principal cantonments in the hills, thus: See Table XVIII.

It will be seen that in both cases the rates decreased to, roughly, one-third in the second period as compared with the first, and that while the decrease in the proportion of men at the most susceptible age was inconsiderable, there was a far

TABLE XVIII.

Plains Stations.

	Strength *Per cent.* of total.		Enteric Fever rates *Per mille.*	
	Under 25 years age.	Up to 2 years' service.	A.	D.
1897-98 ...	51·4	39·5	55·3	17·05
1900-01-02 ...	44·3	20·9	19·7	5·57

Hill Stations.

	Strength *Per cent.* of total.		Enteric Fever rates *Per mille.*	
	Under 25 years age.	Up to 2 years' service.	A.	D
1897-98 ...	58·2	51·4	52·4	8·4
1900-01-02 ...	48·8	22·9	14·1	2·9

greater contrast in respect to those subjected to their first experience of the country; it is to the latter influence, therefore, that the results must be ascribed in larger measure.

The chart showing the incidence on the different service periods should be studied in this connexion, p. 78. The effect of the diminution of the strength exposed in the first period in 1900 and in the first two periods in 1901 is remarkable and is to be traced in the subsequent experience of the same men in the following years. The characteristic step-like fall of the columns is broken by irregular depressions which mark the passage of these men through the successive periods, year by year. Further, the exceptionally low incidence on the first year period in 1903, when the strength exposed at that period was restored to the normal proportion, must be attributed to the fact that the great majority came from South Africa with experience of the disease and of a sub-tropical environment.

We may, therefore, conclude that a factor, distinct from age-liability, does indeed operate, and to an extent that gives it a very important rôle in the etiology of the disease ; it is doubtless a complex of the influences that connote the physiological mal-adjustment of the organism reacting to the stimuli of an alien environment. This indeed is what might be expected, and a laboured demonstration might be deemed superfluous, were its obvious implications not overlooked. Precisely the same influence has long been recognized in Europe, since Murchison first drew attention to it in the special liability to attack to which strangers in London are subject during the earlier period of their sojourn. It can be shown to operate in India at all ages, and to involve a special liability to many of the other causes of the morbidity and mortality ; for the rates are found to fall consistently with each year of service until the latest periods are attained when this influence again asserts a special morbid and fatal force, but doubtless a more indirect one, largely due to the sequelæ of previous disease acquired during the process of adaptation, and also to the disability of advancing age, when the powers of adjustment (resistance) fail. But the later manifestation of this influence is to some extent bound up with the former, and a study of the factors involved may certainly be expected to bear fruit in measures which will promote the increased health and efficiency of the army in India at all periods of service. (Chap. II.)

If, as has been said, the organism is shaped by adaptation to the forces of the environment as the bed of a river by the stream, any sudden and marked change in the environment will produce a more or less temporary disharmony or mal-adjustment in the play of the reacting forces. A complex organism physiologically adjusted to an island climate in the temperate zone, when suddenly transferred to a "continental" climate in the tropics, must undergo a strain on the organic functions which involves their impairment and derangement during the process of adjustment. This, indeed, is manifest within the limits of any one country for an adapted race, in the seasonal distribution of the chief diseases to which the race is liable. It is much more obvious in some cases than in others, according to the powers of adaptation ("resistance"), and to the extent of the variations in the environment, and no better example could be quoted than that of India, as shown by the medical statistics of both natives and Europeans. It is impossible to present the facts in detail in this place, but a few general considerations may be set forth as bearing more immediately on our subject.

The physical environment, including climate, moulds the physiological characters of a race and through them the "domestic" customs (diet, clothing, housing, &c.) which are the artificial means of adaptation. And so we may even discover in the different races of the same genus, broad structural variations developed by selection under the influence of different conditions; we may indicate especially such variations in the relative size, structure and function of the thoracic and the abdominal viscera and the skin, the excess of one being, to some extent, complementary to defect in the others. Compare the lungs of a carnivore (dog or tiger) with the abdominal viscera of the ox or horse, and the similar, but less pronounced, contrast in the organic equipment of the higher races of men inhabiting the higher latitudes, with their concentrated "animal" food, and that of the less civilized "vegetarian" of the tropics. In the one the lung weight and capacity preponderate relatively, while in the other the physiological strain is thrown chiefly on the abdominal viscera* in adjustment to climatic and dietetic conditions, and it is established as a very general "law," that the prevalence and fatality of diseases of the abdominal viscera vary directly, while those of the lungs vary inversely, with the temperature, and this as regards distribution both in space and time (season). The general tendency of a low temperature is to raise the blood pressure and render the circulation slower; the amount of carbonic acid excreted and of oxygen absorbed is increased; a high temperature tends to reverse these conditions, which partly depend on, partly result in, corresponding variations in the metabolic processes of the body tissues and in the elimination of waste products. These effects are accentuated in proportion to the extent of the range of temperature, and to the abruptness and frequency of these extremes, and thus an extreme climate, such as prevails in continental India, gives rise to well-defined periodicity in all biological (and pathological) processes. For along with the effect on the human organism in disturbing adjustment and in lowering resistance, we must associate an even more powerful influence on all lower forms of life (and among these the pathogenic micro-organisms) and on the factors (organic and, inorganic) that determine their viability, propagation and spread. Hence a complex inter-action of forces under the influence of the environment, the various factors of which are

* See Trans. Ind. Med. Congress, 1894.

largely inter-dependent and mutually subservient, and the presence or absence of one or more of which may complete or break the chain of causation and determine the character and the seasonal incidence of disease. Hence also the well-marked differences in the pathological resultant observed in different races when exposed to the same conditions which are alien to one and natural to the other, the issue being directed and modified by the stage of civilization attained in each case and by the extent of the contact of the one with the other.

The sketch already given of the physical environment will make it plain that for the young British soldier newly arrived in India, the greatest contrast with the conditions of his natural habitat is to be found chiefly in the prolonged high temperature and its great daily range, *i.e.*, in the extremes of climate, both seasonal and diurnal, which are specially marked in certain areas. The rainfall and the humidity act chiefly, but indirectly, by modifying or increasing the daily range of temperature, by the mechanical influence of the former on the soil and the water-supplies, and by the relation of both to the life processes of the lower organisms. From the very outset the circumstances are not favourable to the required physiological adjustment; the soldier embarks on a crowded transport under the inevitable disabilities of close aggregation with his comrades, and encounters several extreme climatic changes on the voyage, and he is then plunged into the altered conditions which have been described, all within the space of three or four weeks. A ship-load of troops on arrival is often despatched to a dozen different destinations along routes which have been traversed in both directions by many thousands of men annually. Moreover, the journey has hitherto been broken daily by halts at rest camps which must of necessity have been infected and re-infected constantly with the virus of Enteric Fever, if account be taken merely of the risk due to the passage homeward of time-expired and convalescent men. The effects of this sudden exposure to radically altered conditions in disturbing the normal physiological balance, are shown chiefly in excessive cutaneous action alternating with visceral congestion. The lungs are called upon for less vigorous efforts, while the functional strain is transferred to the skin and the abdominal organs in more or less complementary measure. At this period of effort towards adjustment, we may expect embarrassment and defect in the eliminative powers and a general disturbance of the metabolism in the majority exposed, which, if prolonged, will lead to changes in the reaction of the tissues and the blood, to anæmia and to digestive and intestinal derangements. The functions of the nervous system, at first exalted by heat and sunlight, become depressed, and there ensues a loss of control of the vicarious blood distribution essential to the maintenance of health in a warm climate. The vaso-motor system is chiefly affected by this exaltation and depression, and the internal viscera, which are protected, are rendered specially liable to congestions when sudden cold affects the surface of the body. Excessive external circulatory function connotes diminished vital forces, and it is the balance between the normal relations of the vascular and nervous systems that is so liable to be deranged. But it is obvious that a sudden fall in temperature inducing a "chill" and checking cutaneous action, or some error in diet or extra exposure and fatigue, or an attack of Malarial Fever, will often provide the extra strain under which the functions succumb; the visceral congestion is accentuated and an attack of "fever" and diarrhœa is the frequent result. If, under these circumstances, there is exposure to specific infection the chances of effective attack are greatly enhanced, and unfortunately, there is little room for doubt as to the liability of newly arrived subjects to these functional derangements and still less as to the abundant sources of infection. Nothing but the most scrupulous care and attention to all the resources of adjustment, *i.e.*, to all measures of a rational hygiene, exercise and rest, clothing, shelter, food, etc., will avail to minimise the danger during this period; ignorance and lack of self-control on the part of the men co-operate with the agents of disease, fostered by defective sanitation, to form a combination more fatal than the powder and steel of the enemy they are prepared to meet. Some measure of the loss to the State (without taking account of the sickness and suffering involved by this process of adjustment) may be gathered from the fact that no less than 46 *per cent.* of the total mortality and 36 *per cent.* of the invaliding falls upon the men in the first two years of their Indian service, while no less than 62 *per cent.* of the total loss under both these heads is incurred by those less than 25 years of age. The sources of this loss come, in very large proportion, under the head of fevers and bowel complaints (see chapter II.) which are certainly connected, directly or indirectly, with exposure of the young European to the complex influences of heat.

In suggesting a definite relation between this lack of adjustment to the alien influences of the environment and the predisposition to Enteric Fever, for which more direct evidence will be given in the next chapter, we may not lose sight of the effect of other prevailing diseases which have a very definite seasonal incidence, *e.g.*, Malarial Fevers and Dysentery and Diarrhœa, to which the young soldier is especially liable during the first year or two of service. The former, doubtless, not only predispose the subject to other specific infections, but by their prevalence and very defined local and seasonal incidence, probably modify the occurrence of true Enteric in time and place; the latter diseases may possibly afford a measure of protection, the evidence for which will be reviewed in Chapter VIII. But it will be seen, as we proceed, how predominant is the part played by the factor with which we are now directly concerned, *viz.*, the human host, in determining the main features of the whole epidemiological picture. This, indeed, as previously stated, is the point of view that alone provides a key to the complex problem;—a predisposition of the tissues of the host, varying in different individuals, partly racial and innate and partly due to the influence of an alien environment, and upon which the specific stimulus of the disease-agent operates at greater or less advantage according to the circumstances. All the facts connoted by the term "acclimatization" support this view which, as will be seen, has the most direct bearing on practical measures of prevention. While we observe that disturbance of function, and consequently of adjustment, involves a decline in the powers of resistance, the converse is also true; adaptation is developed in course of time by the continued reaction of the same influences. This is shown in a racial immunity due to the elimination of the most susceptible and to the propagation of the relatively immune, but with which, in our present connexion, we have less direct concern, save as regards the effects of this process in the past on the European exposed to special risks of infection under totally altered conditions. But as regards immunity acquired by the individual, we distinguish between the well-known protection afforded by a non-fatal attack and that which is the result of continued exposure and successful resistance, or in other words, of due physiological adjustment of the organism to all the forces of the environment. It is obviously difficult to estimate the force and extent of the latter form inasmuch as we are ignorant of the true extent of the former. Our record of attacks must, from considerations previously advanced, be held to be defective, and we cannot say how much of the fall in the morbidity rates in the later periods of service is due to previous elimination of susceptible subjects and to the innate immunity conferred by advancing age which, as we have seen, is a doubtful quantity, at least up to middle age. But there can be little doubt that much of the immunity displayed in the subsequent periods of residence is left unexplained on these grounds, and that it is due to acquired powers of resistance possibly superadded to innate qualities of the same kind. The process is certainly to be observed in connexion with other diseases, an attack of which is not known to confer subsequent immunity; the Medical Reports afford clear and striking evidence of the fact that, as Bryden said, "the diseases of the unacclimatized diminish year by year as the adaptation to heat influence is perfected."

The more important facts which demonstrate the influence of "previous experience" have been presented in Chapter II. in connexion with the decline of the disease in India subsequent to 1899, and it was shown that similar results have been observed elsewhere. And when we come to study the incidence on corps units (Chapter VI.) we shall see that immunity may apparently assume a collective form, due, on the one hand, to the increase in successive age and service groups of the proportion of men who have been previously attacked, and, on the other hand, of those who have become "acclimatized," *i.e.*, who have passed through seasons of greater or less prevalence without being attacked.

There is one other consideration which should not be overlooked; it is not impossible that the exciting agent of the disease may be much more generally present in the human organism than the clinical and pathological evidence would imply, but that by adjustment to the conditions of his natural habitat the host has gained a considerable measure of immunity. If this be so, a sudden transfer to an alien environment involving mal-adaptation and depression of the powers of resistance, would probably induce pathological results. It has finally to be noted that although the incidence of the disease shows a very general direct relation to the numbers of new arrivals at the most susceptible ages exposed to risk, yet this relation is not absolutely constant, and the history of the disease in India affords many instances of exceptions to the rule. Such deviations cannot be ascribed to defective diagnosis, as, in the first place, they have occurred subsequent to the general recognition of the disease in India, and a fall in the rates has coincided with a larger influx of young men; and, secondly, a fall in the total fever death-rate in the same years has confirmed the recorded decrease in Enteric Fever. Here we must evidently look for the operation of some other factor, and in all probability to the influence of the environment on the human host, a view which is supported by the comparative healthiness of the years in question in regard to the sickness and mortality from most other forms of disease, *e.g.*, in the year 1881, when the Enteric rate fell to 5·6 *per mille* from 8·0 in the previous three years and when the sick and death-rates from all other causes were exceptionally low. Some part of the fluctuations in the rates in the same localities from year to year, and in different places in the same year, may be attributed to the same influence favouring adjustment ("acclimatization") or to the reverse process, when all the other conditions are the same: it will also be shown that the incidence on the southern and coast ("oceanic") areas is far less subject to fluctuation than that on the "continental" area.

With this view of the human host as an essential factor in the disease process we shall be prepared to estimate the value of the evidence, which will be presented later, on the influences of traffic, of aggregation, and of contact (direct or indirect) in places of common resort,—barracks, refectories, latrines, etc.,—which are associated with one of the most important relations of the host and the parasite to be discussed in connexion with the biology of the latter. Meanwhile a few further points bearing on the predisposing influences which affect the individual may be alluded to. These are mostly connected with the personal habits and domestic conditions of life, and may be summed up as defects of personal hygiene. Among these are inadequate arrangements for bathing, which are necessarily most defective in camp and on the march; inadequate provision of under-clothing and sleeping suits which the soldier has to supplement at his own cost if "anxious" to maintain himself in a proper state of cleanliness; the nature, amount and preparation of the food provided by the State and supplemented by the individual, though doubtless greatly improved in all respects during recent years, leaves much to be desired on both physiological and æsthetic grounds. There is the danger of excess on the part of the young and growing adult under the stimulus of the exciting experiences of the new life, which for the first weeks precludes any exercise and which fosters the imperious claims of appetite. It is declared officially that the rations provided require "but few additions," and this is scarcely judicious, as apart from the failure to secure a perfect and scientific adjustment of the needs and resources in this all-important matter, it throws the men on their own resources, and too many of them are either ignorant or self-indulgent under conditions which call for the official admonition to "try and not brood or become discontented or weary of the monotony of their lives in an Indian station" ("*Hints on the preservation of the health in India for British troops*").

It is established that there is a distinct relation between the methods adopted in the preparation and serving of food and the craving for drink, especially in a hot climate,—to say nothing of the results in respect to the dietetic value of the food itself. This subject acquires special importance in relation to the frequency of defective teeth and the oral sepsis too often resulting therefrom; along with imperfect mastication and digestion and its consequences, there is frequently what is practically a foul sewer at the entrance of the alimentary canal, polluting the purest air inhaled and contaminating the most wholesome food and drink. The most perfect systems of house and site drainage and conservancy, of ventilation, water supply, are largely thrown away in such cases, and it can scarcely be doubted that constant access of the agents and products of putrefaction to the intestinal tract is a potent factor in the production of bowel complaints and in inducing fatal septic poisoning when there are lesions of the protective mucous membrane, which, indeed, may even be caused thereby. (Corner, Erasmus Wilson Lectures, 1904). There is a notable absence of micro-organisms from the normal stomach and duodenum, possibly due to the action of the gastric juice, but in achloridia due to digestive disturbances and in anæmia and after excessive sweating, we may expect septic bacteria generated in the mouth or swallowed with air-borne dust to pass unscathed into the lower parts of the intestine, where, if this be deranged, they will set up pathological conditions resulting in various forms of fever. Beyond the foregoing considerations there are the disabilities arising from the ignorance and carelessness of the men in regard to the improper control of the ventilation in barracks, and in their use of the urinals and latrines which often invite abuse by their most unsavoury condition ; as regards urinals, the arrangements are too often such as to encourage urination on the open site in close proximity to barracks and cook-houses. Lastly, the system of water-supply and the methods of its purification, storage and distribution are not, as a rule, calculated to obviate the results of carelessness, ignorance and haste on the part of those for whom they are designed. The subject of the influence of the contact of the soldier with the native population, in special reference to the dangers incurred by the resort to native bazaars and towns, will be dealt with in a subsequent section.

We may now refer to some of the more important points bearing on the third factor, *viz.*, the parasite and its biological characteristics, but confining our remarks to those having a direct epidemiological significance, that is to say, to the relation of the parasite to the human host and to the environment. On the purely bacteriological aspect of the subject reference should be made to the standard text-books ; it is no part of our task to set forth the demonstration of the etiological connexion of the *bacillus typhosus* and its allies with true Enteric and Paratyphoid infections, and this will be assumed as established for all practical purposes. It is obviously impossible to enter into the maze of controversial opinion as to the precise position held by the bacillus of Eberth among its congeners, or as to the exact relative measure of the parts it plays as a pure parasite and as a facultative saprophyte, respectively. We shall accept as our standpoint the most recent views of Koch, and others of scarcely less authority, who maintain that the all-essential fact in its biological relations is its parasitic phase ; that in the tissues and excreta of the human host it can be recovered and identified with absolute certainty as a specific entity, whereas its viability as a saprophyte has been greatly over-rated. The immense body of conflicting testimony derived from the work of innumerable observers during the last 25 years points clearly to one conclusion, *viz.*, that the human host and his immediate surroundings provide the essential conditions for the development, propagation and dissemination of the germ, and that the farther the search is pursued beyond these, the more difficult it becomes to establish facts which are devoid of fallacy and conjecture. The resources of many most able observers have been exhausted in a quest which has derived its sanction from a partial and inadequate and too mechanical view of the forces in operation, for which the so-called "Localist" school is largely responsible, a responsibility which must be shared by Koch himself and his followers as one result of their achievements in establishing the doctrine of the "specificity" of germ "causes" in infectious disease. This partial view, in conjunction with some of the more striking epidemiological facts, captivated the ardent devotees of the new science and led them to overlook the most essential factor in the sum of the pathogenic reaction. The efforts so diverted have certainly not been all in vain, and it is far from our intention to assert that final conclusions have been reached on this aspect of the question, still less that we can afford to ignore the evidence for the saprophytic existence of the germ; for one exclusive view is as fallacious as the other. But, so far, we are forced to regard the exciting agent of Enteric Fever as belonging to the class of the almost purely parasitic contagia, developed doubtless from an originally harmless saprophytic form, and which is capable of maintaining an ectanthropic existence for a comparatively short time, varying with the relative presence or absence of the conditions of its life requirements. Beyond this, propagation in external nature is certainly probable under favourable conditions, and here we recognize the influence of the environment in its restricted sense (pabulum, heat, moisture, &c.), which may also, and undoubtedly does, often determine the dissemination of the contagium and its access (by water, dust, flies, &c.) to the human host, from which as a "specific" entity it derives its origin, and to which it *must* return to maintain its "specific" quality. Whatever view be taken of the broader biological questions involved, *e.g.*, as to the possibility of the development of pathogenic properties by originally harmless germs,—we must return inevitably to the conclusion that the specific quality is bound up with the parasitic faculty. The host, whether recognized as sick (and before and after the appearance of symptoms) or in apparent health, provides the true "soil" for the germ; within his body and tissues it multiplies, by his excreta it escapes and is disseminated during life, and his tissues and excreta retain the infection for some time after death. The older and restricted view led to the practical assumption that only the obviously sick individual was a source of infection and then merely during the period of the attack; our present knowledge admits of a much more extended conception of the rôle of the host as the nidus and disseminator of the germ. We recognize the frequency of variation in the type of the reaction in the form of light and ambulant cases, and it rests upon more than a most plausible assumption,—there is irrefragible proof,—of the viable presence of the germ in the bodies and excreta of apparently healthy persons who have been in contact, mediate or immediate, with the sick. We do not know how long an individual may be a source of infection before the pathogenic reaction declares itself; this is probable from the very first access of the germ to the body, but we do know that the virus may be continuously and abundantly discharged in the excreta of convalescents for many weeks, or months and even years, and these are considerations of absolutely prime import when we regard the conditions;—the close aggregation of large numbers of men at the most susceptible age, and the nomadic character of their service, which provides all the facilities for the transport of infection from place to place.

It is from this standpoint that the epidemiological problem must be examined; the human host as the central factor, as the source and disseminator of infection, and this not only as hospital patient and not merely during the period of illness. The rest will depend upon the presence or absence of further susceptible material, on the amount of this, and on the facilities offered for immediate or mediate contact, aggregation, common places of resort, traffic. These influences alone will largely determine both the extent of an outbreak and its characteristic local and seasonal features, but to explain these fully we must take account of the influence of the environment on both host and parasite and on the ascertained vehicles of transmission from one to the other, which, however, rarely fulfil a more definite rôle of their own than that of providing the means of "mediate" infection.

If then we would unravel its plot we must look to the drama as played upon the human stage, to the succession of hosts in the maintenance of the "specific" race and the chain of infection, the other factors operating in subordination, though often providing the necessary connecting links in the scheme. On this view of the predominant rôle of the human host, one consideration must be emphasized and this in two connections; we have indubitable evidence of the presence of the "specific" germ in the bodies and excreta of apparently healthy individuals, doubtless the more resistant subjects. This, as previously pointed out, may be frequently the case in men at the susceptible age, who would act as carriers and importers of infection and who would in certain cases develop the disease in their own persons later under the strain of physiological mal-adjustment. But we must also take account of the probability of the maintenance of the race in the bodies of older men who never exhibit the clinical symptoms of the disease and who may thus provide the link between one outbreak and another at considerable intervals of time. At every large cantonment in the endemic area we have a large number of men at the susceptible age in close association with each other and with older men during the "cold weather" and at the beginning of the hot season, and Enteric Fever now becomes most prevalent. Many of the susceptible subjects are removed from further risk to themselves by attack, and many more are now transferred to the hill stations, and the disease-curve falls rapidly to its minimum or disappears entirely, to rise again three or four months later during the height of the Monsoon. The possibilities of fresh importation of infection in large stations are, as we shall see, so abundant that we need have no recourse to a hypothetical consideration of the kind in view to explain its presence in many instances, but it is one not to be overlooked in the general problem in dealing with the recorded facts of outbreaks separated by more or less considerable intervals, during which the disease is declared to have completely disappeared. We have reason to believe that separate outbreaks of plague are etiologically connected in a similar way, the chain of infection being maintained in the intervals in the bodies of more or less immune adult rats, until the accession of a fresh brood of young and susceptible individuals provides the material for a renewed epizootic.

The bearing of the view here advanced will be more precisely indicated in the next chapters (Epidemiology) and in the discussion of the practical measures of prevention : we start, then, from the basis of the ascertained facts on the more purely biological side and shall bring the evidence from other sides to the test of this knowledge.

It is now necessary to touch briefly on the more important of the facts connected with the distribution of the disease-agent in the body of the host, its elimination from the body, its viability in external nature and, lastly, the means of its access to other hosts.

In direct connexion with the human host as the chief source of infection stands the distribution of the bacillus in the body and its means of exit therefrom. Recent observers, among the best and most experienced of whom is von Drigalski, have laid stress on the view of the disease as a "bacteriæmia" in contrast to that of a local intestinal infection. *Post-mortem* the bacillus is found in all the tissues and organs, and, frequently, in greater abundance in the thoracic than in the abdominal viscera and excretions, and thus all the excreta may be expected to contain it in greater or less amount. Hence the anomalous and often unrecognized cases of the infection which assume the clinical features of broncho-pneumonia, bronchitis, influenza, meningitis, etc., and hence the danger of infected sputa, etc., and of the dissemination of infection by patients, the true nature of whose illness is overlooked. There is good reason to believe that want of care in disposing of the organs subsequent to *post-mortem* examinations has played a part in the spread of infection. The bacilli have been found in the gall-bladder and in abscesses in various parts of the body, months, and even years, subsequent to recovery from attack.

It would be superfluous to render an account of the results of observations made for the recovery of the bacillus from the blood, the urine and the fæces of persons in different stages of the disease or of convalescence, as well as in the excreta of apparently healthy persons who have been in contact with the sick. Light, or so-called "ambulant" cases may be deemed an even greater source of danger, especially when they occur before or apart from an epidemic outbreak, which may be the first and only indication of the prevalence of the disease. The most recent methods of diagnosis enable us to affirm broadly that the bacilli may be most readily recovered from the blood in the earliest stages of a pronounced attack; that the fæces contain them in greatest abundance during the second and third week (although they have been successfully isolated therefrom during the second and third days) and during relapses; while the urine is the chief vehicle of elimination in the later stages and during convalescence, the infection persisting for an indefinite period, often prolonged through several months. The old empirical association of Enteric Fever with the class of "filth diseases" is thus abundantly justified, and we may affirm the essential facts that in the body of each infected individual there is an enormous multiplication of the disease-agents, extending over an indefinite period, with more or less constant elimination in excreta which are voided several times a day under conditions which expose other persons to the imminent risk of more or less direct contact with these excreta; and finally, that Enteric Fever is due to the transference, mediate or immediate, of the excreta of an infected individual to the alimentary canal (or possibly to the lungs) of other individuals who are susceptible to the infection. It will be obvious that the risks arising from these conditions attending the elimination of the infective germ are greatly enhanced in country places, camps, and cantonments devoid of proper drainage and sewage and disposal systems, and where the water-supply is derived from shallow wells or open sources which are immediately subject to the influence of a tropical rainfall. Given the infective agent we see how it may be broadcast in more or less close proximity to the human host who is exposed to direct contact with it and with others, while every facility exists for the mediate transfer of the infection in the various ways to be described later.

As regards the viability of the bacillus in external nature, the amount of research carried out by innumerable observers and the literature embodying the results are literally enormous, which is almost tantamount to saying that these results are often very conflicting and far from conclusive. This is largely due to the facts that different methods have been employed under varying circumstances, that the personal equation varies in each observer and that many researches have been undertaken to support *à priori* views. Much of the mass of recorded opinion may be swept out of account because it was based on very defective technical methods which did not exclude the fallacy of confusing Enteric-like organisms with the true bacilli. And even when we come to deal with the small remainder of more authentic work we must always be on guard against the too facile assumption that results achieved in the laboratory apply conclusively to the complex conditions of natural phenomena. In all cases, viability outside the body of the host depends almost entirely on the circumstances; an artificial culture exposed in a thin layer to the direct rays of the sun and to a current of dry air will die out very rapidly, but if the bacilli be included in a mass of fæces, or rolled up in a blanket, or sheltered in moist organic matter under the finger-nails, they may retain life and virulence for an indefinite period. Conditions of pabulum, of temperature, of moisture, of sunlight and the presence or absence of competitive micro-organisms all affect the issue, but as a general rule it may be affirmed that, even under favourable circumstances, the bacilli eliminated from the infected host are not adapted to a saprophytic existence in the fullest sense; they may and do often maintain viability but are mostly incapable of the prime function of propagation. The practical point is that during this stage of animation they are capable of being transported on the bodies and clothing of men, on and in the bodies of insects, on various articles such as food and cooking vessels, and undoubtedly in dust, especially when not devoid of moisture, and that they thereby gain access to new hosts directly, or by means of food and drink exposed to contamination. Certain articles of food present a specially favourable nidus for the growth and multiplication of the germs thus introduced, *e.g.*, milk, bread, potatoes, etc., and herein viability outside the body in its fullest sense is conclusively established, and such contaminated foods often provide the link in the chain of infection between cases.

The question of viability in water and in soil has, perhaps, received the most assiduous attention, and here, again, almost everything depends on the conditions, *e.g.*, as we see them contrasted in a shallow stagnant well subject to continued re-infection, and in a rapid mountain stream open to the influence of air and sunlight; or, again, as we find them in the moist organically polluted earth of a latrine or barrack and its shady environs and included in fæcal masses just below the surface soil of the trenching ground, or, on the other hand, exposed on more or less impermeable rock or pure dry sand to the fierce rays of the sun. In regard to water, the most reliable of recent experimental results afford no definite standard for practical application; it may however be said that in unsterilized water the bacilli do not, as a rule, maintain life beyond two to three weeks, whereas in sterilized water they may persist for several months. We must reiterate the fact that in both cases much depends on the accompanying conditions and that the bacilli often die out at once where the conditions as judged by laboratory analogies do not appear to be unfavourable, and in all cases, propagation of the germs in water is the exception (Kolle and Wassermann). It is however notable that the presence of certain sewage salts in the water, and especially of nitrates, has been shown by

Klein to be distinctly favourable to viability, a fact of great importance in its bearing on Indian conditions; we have a fæcally polluted soil, with frequently a high-level ground-water which fluctuates rapidly under the influence of tropical rainfall, and which is tapped by the innumerable wells which afford the usual sources of the drinking supply. We may not, therefore, ignore the abundant and reliable evidence pointing to the direct association of specifically contaminated water with outbreaks of the disease; there are instances, the authenticity of which is undeniable, of the recovery of the true "specific" bacillus from the water and where no doubt can exist of its causal connexion. In other cases the evidence, though indirect and circumstantial, is, to all intents and purposes, equally cogent and convincing. As regards Indian experience in this respect all that may be affirmed definitely is the fact that large numbers of water-samples are submitted annually to bacterioscopic tests and with frequent positive results in the opinions of those responsible for the diagnosis; but it is very noteworthy that as Enteric Fever has increased, and as technical methods have become more complicated *pari passu* with the recognition of the multiple pitfalls involved in diagnosis, these alleged positive results have become both relatively and actually rare, and now a year may pass without one.

When we examine the evidence as regards the viability of the bacillus in soil, we are on even more doubtful ground. We do not impugn the results of the well-known researches of Sidney Martin, of Pfuhl, Losener, Firth and Horrocks, to name those chiefly associated by their work with this aspect of the subject. These results have a very definite value in indicating certain of the conditions that doubtless operate in nature to provide links in the chain of infection, but they are certainly subject to the reservations we have specified and do not constitute proof of a true saprophytic faculty in its complete sense, under ordinary conditions, such, for example, as the school of Pettenkofer and the "Localists" would contend for. Short of this, and that the bacilli can and do maintain existence under favourable conditions and for indefinite periods in soil contaminated with infected excreta, there can be no reasonable doubt; moreover, as in the case of water, such conditions are provided where nitrates are present, where the bacilli are included in fæcal matter and where the requisite temperature, moisture and shade are available. When cultures of the bacillus are mixed with dust or pulverized earth, and when completely desiccated, death speedily ensues, but when desiccation is not complete the bacilli may retain their vitality for many days, weeks, or longer. It is certain that particles of dust which may be carried for considerable distances in currents of air, are frequently not completely desiccated. The experiments and conclusions of Germano and Neisser are often referred to in regard to the possibility of infection at a distance by this means, and Firth and Horrocks have more recently demonstrated that infected dust is capable of infecting distant objects as long as 24 days after the desiccation involved in raising and transporting the dust. And even were the experimental facts more adverse to this conclusion, we should not be justified in rejecting the evidence which has accumulated in its favour during the campaign in South Africa and also in America in the Camps mobilised for the Spanish war (1898), to the records of which the reader must be referred. No superfine bacteriological evidence of the actual presence of the bacillus is required when dinner in Camp is rendered impossible owing to the cloud of dust accompanied by fæcally-polluted paper from the latrines, which, in one instance at least, was described as enveloping and descending upon the persons and the table of the diners. A summary of an account by Lieutenant-Colonel Davies, R.A.M.C., on an outbreak of Enteric Fever at Quetta in 1898, which was attributed to infected fæcal dust derived from the trenching grounds and borne by wind to the barrack sites, is given in the Sanitary Commissioner's (India) Report for that year, and forms a valuable contribution to the elucidation of one aspect of the epidemiological problem in India.

Coming, in the next place, to a slightly different aspect of the question, *viz.*, the possibility of the localization and viability of the bacillus in the dust and on the structure and furniture of rooms, barracks, etc., we find records occasional, but suggestive, of outbreaks that make this possibility one for anxious solicitude, the practical indication being thorough disinfection of all quarters and furniture, etc., occupied and used by men in any stage of the disease. After the Franco-German war it was found that Enteric Fever continued to prevail for some years in German garrisons in which German troops or French prisoners had been attacked. The Commissioners who reported on the origin and spread of Typhoid fever in the U. S. military Camps during the Spanish war, give details of instances of barrack infection transmitted to corps occupying the buildings after their evacuation by troops among whom the disease had prevailed, and where other sources of infection (water, clothing, etc.) were excluded. The whole subject of the localization and viability of the germ in external objects, water, soil, barracks, camp sites, etc., derives additional importance from the consideration of the danger incurred by non-infected men subsequently occupying the site, and we shall adduce pertinent evidence on this point when we come to deal with the epidemiology of the disease among men in camp and on campaigns.

Lastly, we need not linger over the well-established fact of the viability of the bacillus in textile fabrics, tents, clothing and bedding. Here again, experimental bacteriological evidence is available to confirm empirical experience. Nothing more striking and conclusive need be referred to than the case of the South African blankets, by which infection was introduced into various places in Great Britain, and which were reported by Klein to contain innumerable bacilli. Nothing moreover is more liable to frequent and abundant and direct contamination, nor more likely to convey infection by the circumstances of its uses and manipulation by different individuals.

We may now sum up, as briefly as possible, the main conclusions at which we have arrived concerning the sources of infection, the conditions for its propagation and dissemination and for its access to the body.

1. The human host is the chief and original source of infection, and the true "soil" for its propagation ; the maintenance of its virulence and the reinforcement of the race is effected by the transfer to other human hosts. Further, man himself is the most active and important agent in the dissemination of infection, which he may carry in his alimentary canal or other organs (notably the urinary passages), on his person or in his clothing and other effects. In this way the specific virus may be transported to any place at any distance, the facilities varying with the rapidity and extent of traffic and the frequency of intercommunication. An infected subject may deposit innumerable bacilli in one or more latrines of his regiment and on the barrack site and in his dormitory, long before he is suspected to be suffering from the disease, and may continue the process long after he is discharged "cured" from hospital. From the widespread distribution of the disease and the special liability

to it at the soldier's age, every regiment at full strength may be assumed to include two or more infected subjects at some period of every year. Cases in which the disease is recognized are most dangerous to others before and after they come under treatment in hospital ; a very large, but indefinite, proportion of cases is never recognized, occurring as light "ambulant" or afebrile attacks or simulating other forms of "fever." It is, further, possible for a man to carry and excrete the bacillus in its virulent form, without presenting any obvious clinical symptoms, and possibly the older and less susceptible individuals, who may or may not have suffered previously from an attack of the disease, are included in this unconscious and unrecognized band of cultivators and disseminators of the bacillus, and so may maintain the race and the chain of infection between ostensible outbreaks. We shall here affirm the view that, for all practical purposes, Enteric fever is, in the great majority of cases, imported into cantonments and camps by infected members of the units (regiments, batteries, etc.) there located or arriving and passing through ; we shall endeavour to establish this proposition on a firm basis of evidence in the sequel. Much confusion and error have been imported into the epidemiological problem by ignorance or non-recognition of the facts stated above, and by the too rigid interpretation and application of the text-book statements as to the period of incubation of the infection. Apart from the debateable question of the "latency" of the bacillus in the body for considerable periods before effective infection takes place, many of the cases of so-called prolonged incubation after exposure can be explained best on the view that the infection has been carried on the person for some time before it obtains effective lodgement in the body, *e.g.*, under the finger-nails, in the hair or clothing. Similarly, the clue to the origin of infection may be overlooked where the conditions are favourable to the viability of the bacillus altogether outside, and apart from, the human host, as in the case of men arriving in a cantonment or camp previously infected.

2. With these facts and probabilities before us, and bearing in mind what has been said as to the character of the *personnel* exposed (age, etc.) and of the conditions of life in cantonments (aggregation, common places of resort, latrines, dormitories, refectories, nature of the sources of water-supply, etc.), we have to distinguish broadly between two chief methods of dissemination of the infection. The first is that by which a

body of men, larger or smaller, are simultaneously infected from a common source, as in outbreaks in a company or among the inmates of a barrack, or as prevailing generally throughout a regiment or garrison; and secondly, that which is incompatible with the assumption of a simultaneous and continuously acting agency as the chief means of origin and spread of the disease. The former type is that ordinarily associated with the contamination of a common water or food supply, while the latter finds its best exemplification in individual personal contact with the sources of infection. But it is obvious that in proportion to the abundance of these, to the number of susceptible individuals exposed and to the opportunities of exposure, the latter type will assume certain of the characters of the former. Now, having regard to the notable differences in the conditions under which civilized urban communities and the troops in Indian cantonments and camps live, we should expect corresponding definite contrasts in the epidemiology of the disease; it could scarcely be otherwise, as, indeed, all the evidence tends to show. This is not to affirm that one exclusive method of dissemination is invariably in operation in each case respectively; we see both methods operating in either case according to the circumstances, but the different communities each exhibit a distinctive and prevailing epidemiological type the key to which is different. As the facts are set forth this will appear in due course, meanwhile we are more directly concerned with the means of dissemination which are specially favoured by the conditions existing in Indian cantonments and military camps.

3. The human host being the chief source and disseminator of the infection, it is obvious that the infected individual and his excreta must claim our first and most assiduous attention as the centre of danger to others. This danger is in proportion to the closeness of the contact of the susceptible individual (or other effective host) to the infected host; that is to say, we distinguish between direct and indirect contact, but, obviously, the latter, if effective as regards the infective material, is as dangerous as the former. In the one case the infected excreta of a patient may contaminate the hands of a nurse or hospital attendant and so be conveyed, in the absence of disinfection, directly to the mouth or indirectly by food infected by the hands; in another case flies from an Enteric ward or *post-mortem* room may alight upon and infect the food in a kitchen or dining room; in another case, bacilli

deposited in a latrine may be transported on the person or clothing to find subsequent access by hands or food to the mouth. This view of "contact" infection in the wider, mediate or indirect, sense may, indeed, be extended beyond due bounds, but rightly taken it connotes a definite mode of dissemination distinct from those which have too long and too exclusively been held to explain the sources of infection, *viz.*, a contaminated common water-supply or some occult influence of the environment ("soil" or "localist" theory). Used as a key to the problem, and not as an exclusive dogma, it serves the paramount purpose of directing attention to the original and chief source of infection, the human host, while it does not ignore the importance of securing all measures of conservancy in regard to water-supplies and the disposal of excreta. Concentration of effort in the chase and extermination of the bacillus in external nature is too often analogous to the search for needles in a haystack, and is a diversion of more fruitful measures which should be applied, in the first place, to the source of infection, while maintaining, *at all times*, a systematic and vigilant system of hygiene. While the danger of infection by contact has long been recognized, but as a minor factor in the epidemiology of the disease, it is to Koch* that we owe it that our eyes have been opened to its full significance and to the predominant part it plays in endemic outbreaks in rural areas, in which we find conditions closely analogous to those prevailing in Indian cantonments and military camps. If regard be paid to what has been said in previous pages, it will be admitted that where these conditions differ to any extent in India they are generally favourable to this method of dissemination; we have, to put it as briefly as possible, an aggregation of highly susceptible subjects in close mutual contact under the conditions of a rural civilization in a tropical or sub-tropical climate, and we may find very definite analogies in these circumstances with the epidemiology of endemic Enteric Fever in rural areas in Europe, together with that of Diphtheria among children under what is called "school-influence." This determines the characteristic incidence of the disease on the *personnel* and in time and place; we have a local focus of infection, which

* "*Die Bekampfung des Typhus*" (1902); and the results which have been achieved by the application of the views set forth therein may be studied in various articles which have appeared in the continental medical journals and elsewhere during the past two years, notably those by von Drigalski, Professor Frosch and Talayrach.

by contact, mediate or immediate, may be multiplied into more or less scattered foci, an outbreak taking the form of a chain of which scattered individual victims are the links; or there may be larger or smaller group infections (barrack or company) extending round a focus, with, occasionally, more extensive, indiscriminate, explosive infection of the whole susceptible community, depending on the more or less exclusive operation of contact or occasional exposure to a common source of infection (*e.g.*, contaminated common water-supply). In subsequent chapters the facts will be brought to the test of these propositions; we may note in passing that, during the last 10 years in India for which records are available, out of 15,874 reported attacks, 301 were recognized in hospital among patients admitted for other diseases or among attendants on Enteric cases. This yields a much higher ratio of hospital infections than that recorded in European experience, which is well below one *per cent.* (Kolle and Wassermann.) Further, it is a remarkable fact having the most direct bearing on this aspect of the subject, that among 111 fatal cases of the disease in 1903 (*i.e.*, in 40 *per cent* of the total for which details were given) the average duration of the attack, from the date of recognition to the fatal issue, was only 6·8 days. The average duration for *all* fatal cases was 16 days, but this includes many cases extending over several months,—up to as many as five months in some instances. The results in 1904 are almost identical and are due chiefly to the failure of the men to "report sick" until a dangerously late stage of the disease; their importance lies in the evidence they afford of the widespread dissemination of the infection extending over weeks by each infected individual, many of whom are not recognized as suffering from the disease and many of whom, again, never come under treatment.

Lieutenant-Colonel Davies, R.A.M.C., has recently summarised the evidence available from hospital experience in England, as follows: Infection from patient to patient in hospital is very rare, there being only about one or two cases annually in all the London hospitals. In the military hospitals there have been only 19 cases in 1,410 admissions for the disease in 11 years (1·34 *per cent*). Infection is transferred from patients to nurses in hospitals more frequently; every London hospital has about one such case every year. In military hospitals in England this accounts for 2·62 *per cent* of the admissions, the "nurses" being orderlies. The Asylums Board statistics show 127 cases among the nursing staff in the last 8 years.

In the opinion of many experienced Medical Officers of Health in England about 1-10th to 1-7th of the total cases occurring in ordinary practice owe their origin to direct infection from contact with the sick.

Colonel Davies discusses the change in opinion that has developed in recent years, and the conflict of recent experience with the pronouncements of the text-books in regard to this question, and he suggests that there may have been a change both in the nature and quality of the infection—an increase in its contagiousness—and in the bodily constitutions of the population exposed to it. The latter condition he is inclined to ascribe to the great development of sanitary measures and to the greater protection of children from Enteric infection; a generation has thus arisen which is more susceptible, owing to the diminution of previous attacks and of that measure of immunity which is derived from living in an insanitary environment (*Journ. R. A. M. C.* May, 1905); see argument Chap. IX.

In dealing with the question of the viability of the bacillus in the body of the host and in external nature, brief but sufficient indications have been given of the part played by water, soil, air-borne dust, food, flies, clothing and other contaminated effects, in promoting mediate and local (site) infection, or more general outbreaks. The literature of this aspect of the subject is enormous and it would be superfluous to discuss it here; we are merely concerned to indicate the broad and best-established conclusions and their bearing on the problem, while leaving their definite application till we come to deal with the facts. But it may be added that no direct connexion between infection in the lower animals and in man has yet been established. Flies, as has been noted, play their part as vehicles, and the bacilli have been found intact in their excreta; the dung of domestic animals provides a favourable culture medium for these pests, and their prevalence at certain periods of the year may afford a partial clue to the seasonal incidence of the disease. It is necessary to allude also to the part played by rats in linking-up latrines and drains with water-supplies (wells) and food materials. Where rats abound and wells are the only available water sources and these are shallow, the rodents, which are thirsty creatures, burrow down to the water level and often fall in and are drowned. There is also some similarity in the local and seasonal incidence of Enteric Fever and of Plague, the connexion of which with the habits and the prevalence of rats is now well-established. There are also carrion birds and scavengers among the domestic animals (*e.g.*, pigs, dogs and cattle) to be taken into account; these consume fæcal filth, and may not only act as carriers of the infection, but by passage through their intestinal viæ, the common fæcal organisms may possibly undergo a change in their biological properties, to an enhancement of their pathogenic powers and virulence. Calves suffer from enteritis, cows have pathological relations with man, and the recent discovery of the association of goats with Malta Fever through the milk of these animals, may not be overlooked.

We accept as conclusively proved the viability of the bacillus of Enteric Fever outside the body of the human host, with due reservations as to the extent of that viability under the controlling influence of the environment and the general conditions in force, but at the same time we look rather to importation, or re-importation, of the infection and to the maintenance of the race in the body of the host, and thence to the establishment and reinforcement of local foci of infection, than to a constant and definite saprophytic faculty of the bacillus.

In conclusion, a few remarks must be offered on the vexed question of the exclusive "specificity" of the *bacillus typhosus* (Gaffky-Eberth) as the effective agent in the disease process, and on the allied forms of infection known as "Paratyphoid" fever. The bacillus typhosus is a member of a large group of micro-organisms having close morphological and biological affinities but varying in their parasitic (and pathogenic) and saprophytic faculties. It includes, besides the only too-well known and ubiquitous *b. coli* (Escherich), the dysentery group (Shiga, Flexner, etc.), the organisms of meat-poisoning (Gärtner, Basenau, Fischer, etc.), the "paratyphoid" group, represented by several members at present generally described by the names of their first observers, and some others. So far as these are known to be pathogenic for man, there is the general tendency common to all to the production of a systemic toxication, variable in extent, which has a definite local association with some gastro-intestinal lesion or necrosis; the site of election of the local action of the *b. typhosus* is the lower part of the small intestine, that of the dysentery bacilli is mainly the large intestine, while the paratyphoid organisms may either leave no local injury, or affect the large and small intestines indiscriminately; and thus biologically and pathogenically we may recognize certain generic affinities between the whole group, just as if they were descendants of some one common ancestral form, but developed by evolutionary forces on more or less divergent lines to their present "specific" differentiæ. The demarcation between true parasites and true saprophytes is not absolutely defined owing to the existence of the group of "conditional" parasites; there is evidence to show that a saprophyte under altered life conditions can produce pathogenic effects, and a microbe, which under one condition is an ordinary saprophyte, can raise itself not only to parasitic life and pathogenic action, but to a parasitic action which is "specific"*—*e.g.*, certain species of diphtheroid bacilli (Klein). One, and perhaps the main, condition for this evolution of the specific pathogenic faculty, is repeated passage through the body of the host; while, on the other hand, parasites may lose their virulence, *i.e.*, their parasitic pathogenic faculties, when exposed for more or less prolonged periods to the conditions of a saprophytic life. We must then postulate a former and original stage of pure saprophytism, from which, first, "conditional," and, finally, purely "specific" parasites have been evolved, broadly concurrent with the process of the evolution and civilization of the human host, which, as we have seen previously, is an essential factor in the pathogenic process; and with this, we recognize the reversed play of the forces in operation, specific parasites reverting to the purely saprophytic stage of existence in the absence of the necessary host. This view is certainly based on well-established biological facts. In the unicellular organisms (bacteria) there is no distinction between body cell and germ cell; such organisms are reproduced by division, and if, therefore, anyone of them becomes changed in the course of its life by some external influence (passage through the host) and thus acquires "specific" characters, the method of reproduction ensures that the acquired specificity will be transmitted to its descendants. This consideration derives additional force when the enormous number of generations to which an individual may give rise, during even a short sojourn in the body of the host, is taken into account. If, therefore, the individuals of a unicellular species are acted on by any strange (to them) external influences, it is inevitable that

* In regard to the use of the term "specific" it is important to remember that amongst pathogenetic organisms in general, there is as little constancy of pathological potency as of morphological characters or chemical activity.

hereditary individual differences will arise in them, and it is indisputable that such changes are thus produced and that the resulting characters are transmitted in increasing degree through the generations under the continued stimulus of the altered environment. And, on the other hand, the host will gradually evolve a greater power of resistance to the specific pathogenic stimulus by virtue of the selection of the fittest to withstand it, *i.e.*, by the elimination of the least fit, and this in proportion to the pathogenic faculty evolved by the micro-organism and its fatality ; on this fact depends the phenomenon of varying individual "predisposition," of which we have seen the importance. This, by the way, provides a clue to broad problems of national or racial epidemiology, as determined by the stage of civilization attained (settled aggregation under urban conditions or scattered nomadic communities), by traffic, intercourse, growth of population, etc., as also to those of the rise and wane and disappearance of epidemic and other infectious diseases. It has also a pertinent application to the question of the prevalence of Enteric Fever among Natives of India, as to which more will be said at a later stage.

In the writer's opinion the epidemiological facts in regard to Enteric Fever in the army in India may demand for their elucidation, some departure from the doctrine of the "specificity" of the *b. typhosus*, for it is impossible to ignore the bearing of the foregoing considerations. We cannot overlook their significance in view of the certainty of the prevalence of Paratyphoid infections (in which the pathogenic process is indistinguishable from true Enteric) and of the well-accredited records of the occurrence of anomalous fevers and bowel complaints which precede and accompany outbreaks of the disease ; records which are a constant feature of the medical history of the troops during peace and war in tropical and subtropical regions. We have also to account for the "specific" pathogenic *facies* which an infectious disease, when widely prevalent in a community, impresses upon other acute diseases occurring at the time and which are demonstrated both clinically and by *post-mortem* examination. Witness the prevalence of simple acute diarrhœa in Cholera epidemics, the prevalence of diphtheroid affections and the widespread diffusion of the pseudo *b. diphtheriæ* when true Diphtheria is rife, and the frequent occurrence of intestinal lesions simulating those of Enteric Fever in the bodies of persons dying from accidents and from totally distinct diseases during epidemics of Enteric (Liebermeister, Kolle and Wassermann). These phenomena, of which no one entertains any doubt, as also the great variation in the type of the disease prevailing at the same time in different places, or in the same place at different times, may be attributed in large measure to the influences mentioned and to the rapid and continued passage of the bacillus, at one or other stage of its parasitic faculty, through the bodies of more or less susceptible hosts, the results varying with their powers of resistance and with the influence of other "predisposing" diseases of a similar but non-specific kind (*qua* Enteric). We have already referred (Chapter II.) to the evidence of an intestinal reaction of a necrotic character, associated with true Malarial Remittent Fever of the more malignant types, and the whole subject has more than a purely academic interest, if only in regard to the question of diagnosis and so to the completer recognition and control of the sources of infection.

Again, in this connexion, we may not overlook the modifying influences of mixed infection and of the symbiotic faculties of different (and often closely allied) micro-organisms. When a man drinks contaminated water or ingests infected filth in any form, he never incorporates a pure culture of the specific bacillus, a fact that discounts the value of so many of the experimental results obtained in the lower animals. Moreover we have to reckon with the intestinal flora present at the time, or subsequently, and with their action both on the specific bacillus and on the body of the host. Some important observations made by Sanarelli and by Chantemesse and Widal are worthy of recollection in this connexion. Their results, while convincing them that the *bacillus coli* preserves its identity under all circumstances, and does not tend to merge into the Typhoid bacillus, showed nevertheless that the former organism is capable of exercising an important influence on the origin of, and on the pathogenic process in, true Enteric Fever. As long as the intestinal canal is in a healthy condition, the bacillus coli is harmless and is non-pathogenic for animals, but there are numerous observations from all parts of the world to show that when the resisting power of the intestinal wall is lowered, and multiplication of the microbe is favoured by circumstances, the *bacillus coli* is capable of setting up pathological processes of all degrees of severity both within and beyond the intestinal canal, and it then becomes pathogenic for animals. But the most important observation made by them is that the soluble products of *bacillus coli*, as well as of *proteus vulgaris*, the *streptococcus*, etc., bring about, both in the intestine and in the body generally, a state of matters very favourable to the virulent action of the typhoid bacillus, so that abnormal activity of the *bacillus coli* may, on the one hand, determine an attack of Enteric fever in an individual, if the typhoid bacillus enter his body at that moment, or is already there, or, on the other hand, it may bring about a relapse in a case in which the tissues of the body had almost gained the victory over the Enteric bacillus. It is also known that in the course of Enteric Fever, the *bacillus coli* multiplies greatly in the intestine. Further, Klein has recently adduced evidence showing that bacteria belonging to the *enteriditis* group of Gärtner so frequently present in sewage, when ingested along with the Enteric bacillus, may not only increase the susceptibility of the tissues of the host by setting up an enteritis, but that they may also enhance the virulence of the latter. Hence the importance of all measures of conservancy and the prevention of the more common bowel complaints, apart from their direct bearing on the suppression and removal of specifically infected foci. Sanarelli also found that long exposure to humid heat produces grave functional disorder of the abdominal organs and especially of the intestinal canal, which favours auto-toxication, rendering the subjects more susceptible to certain infections, so that an attenuated virus, innocuous to the healthy, will produce fatal effects; here again we may see the effects of heat influence operating both on the tissues of the host and also on the intestinal micro-organisms normally present or accidentally ingested. It may be said that Sanarelli's results have since been confirmed by Lorrain Smith and Houston, and by Biberstein, as well as, indirectly, by the numerous observations which have been published of the results of the serum reaction which, in many cases, gives positive results in higher dilutions with the *b. coli* than with the *b. typhosus.*

Dr. Row, of the F. D. Petit Laboratory, Bombay, has recently adduced forcible evidence in favour of the view that certain obscure continued fevers which occur among Natives and which simulate Enteric in many of the characteristic clinical features, are due to the pathogenic faculties assumed by *b. coli*, or to mixed infections in which *b. coli* and organisms of the *b. enteritidis* (Gärtner) group are concerned (*Trans., Bombay Medical and Phys. Soc.*, April, 1905). Only two out of 24 cases presented in this communication gave evidence of a pure *typhosus* infection, and we may anticipate the more detailed discussion of the question of the prevalence of true Enteric Fever among natives by one remark. When regard is paid to the universal fæcal pollution of the sites occupied by native communities, and to the primitive disregard of the simplest hygienic rules that characterizes their habits, we should expect Enteric Fever to be relatively very prevalent, for fæcal contamination of food and water must be constant and universal. But whatever conclusion be drawn from the evidence on the main point, it will be clearly shown in the sequel that the resultant of the forces in operation is in strong contrast with the epidemiological features of the disease as exhibited by the European army, and no more forcible demonstration could be desired of the necessity of the more comprehensive conception of the disease process which supplies the key to the etiology. For if the universal distribution of the specific infective agent be granted, the reaction on the part of the human organism in the case of natives must be altogether different.

To sum up these considerations: we may not disregard the probability that the majority of Europeans are, at one time or another, hosts for the parasite and its pathogenic allies; that this hospitality is repeatedly incurred and to an extent of which overt clinical signs fail to give evidence, just as in the case of Tuberculosis where nearly everyone harbours the bacillus and only a minority contract the disease under adventitious conditions which lower resistance. The concurrence and interaction of host and parasite are essential, but beyond this, other factors which operate on one or other or both must frequently be invoked to account for the specific pathological results. As regards the host, there may be some physiological mal-adjustment involving a morbid state of the intestinal tract and its cells and secretions, which deranges the normal control of the micro-organisms present, while, on the other hand, affording conditions for the increase of their virulence which may be raised to the pathogenic point—as we see in appendicitis and in pyæmia and necrosis after operation. It may be a simple digestive disturbance, a chill, an attack of Malaria, which disturbs the biological processes of the cells upon which protection depends, and apart from any question of the evolution of specific pathogenic properties by ordinarily harmless micro-organisms, these may so react upon the tissues under the altered conditions, as to open the way to the invasion of the "specific" agent.

It would be impossible to devise circumstances more favourable to such mal-adjustment than those which affect the young British soldier in every stage of the rapid passage from his home to a cantonment in the tropics, with the sudden and complete change in climate and habits involved thereby. The purely bacteriological conception which regards the agency of the specific parasite exclusively as the sum and substance of the disease-process is therefore misleading: we are constantly at fault in our efforts to mark down the particular germ responsible in each case, and meanwhile important practical indications are overlooked. It is clear that such efforts are entirely justified in any complete scheme of defence, and that they will have to be multiplied and better directed if we are to advance to the end in view, but this will only be attained if they are given their proper place in the more comprehensive conception of the problem here set forth in the terms of the human host, the parasite and the environment and their inter-relations. It is true that we recognize the importance of the host in the facts of the liability incurred by certain ages and service periods, and of the environment in the characteristic local and seasonal incidence, but even so the implications too often evade us.

Paramount among these is the rôle of the host—of the soldier himself—as the source, the ultimate *fons et origo mali*, and the disseminator of infection as well as the essential soil for the evolution and maintenance of the parasitic life processes of the germ, and this not necessarily with constant and invariable pathogenic results which are recognizable. On this view alone can the various facts and difficulties be reconciled, the various theories be reconstructed and the rational etiology be elucidated. And the first step is to recognize that the potential or actual specific agent is much more commonly harboured than the clinical signs would indicate; that the majority of men at the soldier's age are probably hosts at some time and, in many cases, repeatedly; that under ordinary conditions the majority are resistant to pathogenic effects, whether by innate or acquired powers or by lack of due virulence on the part of the germ. Thus we are directed to potential sources of infection and dissemination, which are linked up through mild unrecognized cases (? Simple Continued Fevers) to the more or less typical reactions in the most susceptible minority: the order of events is doubtless frequently reversed, but from whatever point the departure is made the vicious circle may be completed when account is taken of the long period of infectiveness under the conditions of aggregation, contact and intercourse which prevail in the community.

Paratyphoid.—"Paratyphoid Fever" has not yet been given a separate place in the Nomenclature of Diseases and, so far, there has been no official recognition of its occurrence in India; as has been said, the diagnosis of Enteric Fever has rested almost entirely on the clinical and pathological signs, and many supposed cases that have reacted negatively to the Widal test have recently been excluded from the category of true Enteric and relegated to the head of either Remittent or Simple Continued Fever. This, in itself, is significant, apart from any fallacy in the application of the serum test and in view of the fact that Paratyphoid often runs a light and aberrant clinical course with an absence of diarrhœa and of the local intestinal reaction (ulceration). Moreover, Firth has described cases observed by him among the troops in what we shall hereafter find to be the area of endemic Enteric Fever, as to the paratyphoid nature of which little doubt can exist. Everything, indeed, points to the probability of the prevalence of this form of infection, but we shall have to await the routine application of more scientific methods of diagnosis before we can hope to obtain definite information as to its extent and other epidemiological characters. So far as European experience goes these have very close affinities with those of Enteric Fever: we have records of outbreaks spread by contact and by contaminated drinking-water, but it is still uncertain whether the paratyphoid organism, like the Enteric bacillus, finds its optimum environment and multiplies its kind almost exclusively in the body of the human host—so that each attack is to be traced to a previous infection—or whether it is adapted to a prolonged existence in external nature and then only becomes parasitic-pathogenic under certain favouring circumstances. Its very close biological affinity with the true Enteric bacillus, renders this question one of great importance, for, on the general considerations already advanced, we can conceive the former as occupying a stage of development, that of a "conditional" parasite, which is the forerunner of the true "specific" parasitic phase attained by the latter. And thus what, on clinical and pathological grounds, may often fairly be deemed non-Enteric fevers, may by passage of the agent through susceptible hosts, develop the true "specific" infection.

What we have to recognize is that the reaction to which the term Enteric Fever is generally applied, is not a distinct entity and that we must be on our guard against this assumption. The whole course of our experience in India, the views of the older physicians (as set forth by Sir J. Fayrer in his article in Allbutt's "*System*") and the attempt to repudiate the identity of the etiology of the disease with that known in Europe, while able bacteriologists have upheld the view of the transmutation of *b. coli* into *b. typhosus*, are all significant signs which are not to be condemned off-hand as the fruit of ignorance and obstinate prejudice. And not even the youngest of us are free from the workings of that ironical fate that dogs human (and especially scientific) progress and transforms the truth of to-day into the error of the future. The isolation of true *b. typhosus* in a few cases of Enteric in India (and this before anything was heard of "paratyphoid" and the intermediate members of the Typho-Coli group) although proving that the same pathological process occurs in India as in Europe, does not prove, as must be freely admitted, that all Continued or Remittent Fevers which simulate Enteric Fever, even closely in respect to the clinical sypmtoms, are etiologically identical therewith. And even on the older view it has long been recognized that the *b. typhosus* never acts alone as a pure infection; there is always, in the most typical reactions, a varying degree of co-operation by septic and other organisms which may normally exist in the intestine; no one who imbibes the Enteric virus takes it *au naturel* but it is always mixed with other organisms of like origin, and it finds allies ready to co-operate at the point of danger. Again, neither the virulence nor the variety of the bacilli accounts wholly for the clinical differences in the reaction, nor does its course exhibit any uniform relation to the bactericidal power of the blood. Moreover, the reaction of the tissues is much more extensive and complex than can be accounted for by the simple and direct action of the bacteria and their products; the exhaustive metabolic processes of the body generally, beyond the local tissue reaction, show this conclusively. All this goes to emphasize the larger conception of the disease process which has been previously formulated, and it should open our eyes to the more complex issues involved. But the existence of "Enteric Fever" having once been established, we have been content with the steps thus gained and, in place of an attitude of negation, we have become *plus royaliste que le roi*, and every enteric infection is held to be Enteric Fever.

We need only point to the infrequency of the identification of *b. typhosus* in cases of "Enteric" occurring in the army, to the aberrations from the classical clinical type constantly met with in India and during the Boer War in South Africa, as well as to the questionable *post-mortem* evidence frequently submitted in support of the diagnosis ; true Enteric ulceration being often wanting (such cases being relegated to the Remittent Fever group), or the ulceration diverges markedly from the true type and simulates that of Dysentery in extent and local incidence. The fact that ulceration occurs in many other Continued Fevers of the tropics, is not adequately realized. (This subject is dealt with at length in Chapter IX.) There is, further, as we shall show, a very considerable measure of immunity on the part of natives to true Enteric, while there is good evidence to the effect that the enteric infections from which they suffer are of paratyphoid or paracoli origin. With all this there is the very recent recognition of paratyphoid infection as etiologically distinct from true Enteric, which has reinforced the wider view of the part played by simple entero-sepsis arising from functional derangements of the alimentary tract so common in the Tropics, and which favours the evolution of pathogenic properties in the normal intestinal flora. And, lastly, we cannot avoid the indications provided by the more septic type of the pyrexia in Indian Enteric, and by the sporadic complexion of the epidemiology.

In this connexion we cannot ignore the part played by the Widal-Grünbaum test in the attempt to differentiate the whole group of Enteric infections, which on clinical grounds were formerly held to represent one pathological reaction. Hints to this end were furnished by the light, aberrant or so-called abortive cases and by the modifications in the lesions found on autopsy. It is owing in largest measure to the development of the technique of the serum-reaction, together with improvements in methods of bacillary diagnosis, that attempts are being made to distinguish true Enteric (Eberth) from the class of infections which we designate under the general term "paratyphoid," though this class includes several forms, into the differential details of which we need not enter here. The effective agents occupy an intermediate place between *b. coli* on one side and *b. typhosus* on the other ; and in accordance with their proximity in biological properties to one or other they have been provisionally divided into two groups: "A" (more allied to *typhosus*) and "B" (more nearly resembling *coli*).

In regard to their distribution in the tissues and organs and in the excreta of the infected, they are as abundant and widespread as in the case of true Enteric, which in these respects they closely simulate, and for their isolation and identification precisely similar methods are in use. As regards the serum-reaction for clinical diagnosis, the bacilli isolated may be tested, on the one hand, with an authentic human or animal paratyphoid serum, and, on the other hand, the serum of a doubtful case should be tested with authentic strains of *b. typhosus* and the different members of the paratyphoid class. The weight of evidence which is abundant and daily accumulating, goes to show that while paratyphoid serum will often agglutinate *b. typhosus*, it generally acts upon the paratyphoid bacillus, which is in causal connexion with the attack, in very much higher dilutions, a distinction most marked at the height of the disease. The pathological results of infection are, as a rule, conformable to the clinical effects; that is to say, the picture may frequently stand for an ordinary case of true Enteric, but, as a rule, there are modifications due to the absence of one or other typical feature of the latter, *e.g.*, a lack of the classic lesions of the small intestine and mesenteric glands, while the tendency to pneumonic complications, to hæmorrhages and to pyæmic deposits is perhaps more marked.

It is also notable that there is frequently local reaction and ulceration in the upper parts of the large intestine, so that, roughly, one may perhaps distinguish a tendency to a bridging of the interval between the pathological *facies* of Enteric and Dysentery, the causal agent of which last has certain biological affinities with the whole group under discussion. On the epidemiological side the chief points of interest are the persistence of the bacilli in the excreta of convalescents; the fact, now established on good evidence, that some, at least, of the organisms can maintain their viability in water and in milk and meat (and one sub-class, as we have seen, is specially associated with meat poisoning outbreaks), and also the tendency of the disease to appear sporadically or in relatively small epidemics. Lastly, a good many cases of mixed infection have been described, the paratyphoid organism being found in conjunction with the influenza bacillus, with streptococcus and with true *typhosus*. The best and most reliable example of the last is a case described by Conradi, who affirms that to prove mixed infection it is necessary to demonstrate both organisms, not only in the body of the sick but also in the medium of infection, as he appears to have succeeded in doing.

Beyond the intrinsic practical interest of the subject, for a general discussion of which the reader may refer to papers by Clemens, Kayser, Firth, Fischer and Drigalski, the work here summarized derives a special interest and value from its bearing on the problems of serum agglutination. The discovery of the reaction commonly associated with the name of Widal was hailed at first with extravagant hopes from which there have since been signs of reaction, owing undoubtedly to lack of precise knowledge of the bio-chemical forces in operation, and to a too exclusive reliance on its indications apart from a consideration of the whole clinical and pathological evidence, and frequently in the absence of supplementary bacterioscopic research. It is on this account that the present position of opinion on the paratyphoid question must be received with a certain reserve, for it is based very largely on the results of a single test which, in some respects, has proved itself to possess only a relative value for clinical diagnosis. No competent observer denies that it is a valuable, an indispensable, aid to diagnosis, and it may well be that as knowledge grows, we may find, in its very limitations, surer evidence of its true worth. Various sources of error have entered in to depreciate its value as a criterion;—as regards methods of technique, the inadequate and varying dilutions employed, the use of varying strains of the test organism, and these of different ages maintained under different conditions in laboratories; and in respect to the personal equations of the observers.

This is enforced by the fact, which appears to be well established by Jurgens, Brion and Altschuler, and Stern in their studies of agglutination curves during the course of the disease, that maximum agglutination values may be given by the serum with bacilli which were shown to have no etiological relation to the illness, and further, that the specific agglutination value is not invariably above that of the group agglutination, which, indeed, cuts at the root of the *rationale* of the differentiation of paratyphoid and Enteric Fevers. While this gives pause to our acceptance of many published results and opinions, it does not indicate that we are at the end of our resources; such cases are relatively few, and apart from the effect on the serum-reaction of mixed infection which may be in operation, it is precisely herein that Castellani's procedure (exhaustion of the agglutinins) and Pfeiffer's phenomenon are available and probably conclusive.

The conclusion is that in using the test any decision based on the indications of specificity from arbitrarily fixed dilutions must be avoided; in each case the observer must exhaust the limits of the reaction of the serum on different micro-organisms of authentic identity and origin which may enter into possible etiological connexion with the case, and so refer not to "negative" or "positive" results, but state the facts.

Now, hitherto, little of the kind has been attempted; out of 1,397 admissions to hospital for Enteric in 1904, only 749 were submitted to the ordinary serum test (against *b. typhosus*), of which 526 are declared to have been "positive," 198 "negative," and 25 doubtful. It is said that the bacillus was isolated from the urine in "several" cases, but beyond this, there appears to have been no attempt to identify its etiological connexion with the disease, *e.g.*, from the tissues *post-mortem*, but as to this information is not available. We can only suggest that, taking these results as they stand, there is ample room for a large proportion of paratyphoid infections. It is clear, therefore, that one of the first steps indicated by the present situation is a reform in, and extension of, the methods of diagnosis, to which allusion will be made in Chapter X; for on a differentiation and authentification of the forms of disease we have to encounter, will depend a comprehension of their etiology and the application of remedial measures.

If, now, the reader will recall our definition of the disease process as presented in the opening pages of this chapter, we may sum up our conception as it bears more directly on the position we have now arrived at. And the writer deems himself fortunate in being able to quote the views of a most able clinician, Major D. W. Sutherland, I.M.S., Professor of Medicine at the Punjab University, Lahore, with whom the subject has been discussed; the remarks which follow are his (save for immaterial alterations) and were received when this work had attained the stage of final proof.

Respiratory and intestinal infections are to be regarded as much more varied in their nature (so far as the infecting agent is concerned) than the cut-and-dried text-book statements indicate, and the latter are the cause of many doubtful cases of fever for which it may be impossible to find a text-book label. Throat and oral infections are very common, and often overlooked; "enteric" infections are very frequent, and do not necessarily connote the clinical entity Enteric Fever; while colon infections, either in the cæcum and appendix or in the sigmoid, are only beginning to be adequately appreciated. On the view already set forth in this Essay, we recognize that physiological reaction is constantly taking place and saving us from harm, and that the pathological reaction of the tissues to stimuli (inflammation) is only physiological reaction so severe as to cause discomfort to the individual,—the discomfort and the incompleteness of the inflammatory reaction causing the symptoms, and the physical evidences of the inflammatory reaction the physical signs, of the "disease."

The lower end of the ileum may be regarded as naturally weak, and favourable to the lodgement of infecting agents, because the peristaltic wave dies away there, and because the intestinal contents by that time have lost their acidity. Nature recognizes this and guards the weak place by lymphocyte stations (solitary nodules, Peyer's patches and vermiform appendix) in the same way as she guards the weak place in the skin surface—the conjunctival sac—by the lachrymal secretion and the lymph nodules in the inferior angle. Infection of the lower end of the ileum may come about (1) from above; (2) from below.

From above, the infection may arrive with the food, with the drink, or by swallowing the expectoration. Infection with the food is less likely, for few micro-organisms can resist the acid moat formed by the gastric juice in digestion, although the danger is greater in catarrhal states of the stomach when the juice is feebly, or not at all, acid. Infection with the drink is more likely, for then the saliva and tonsils have not time to exercise their beneficial effects, and the gastric secretion is alkaline when the stomach is empty. That there is a danger we know from our knowledge of cholera, Enteric, dysentery and intestinal tuberculosis, but the contamination of the fluid taken by infection from a previous case, must always be recent, for pathogenic parasites cannot (in water at any rate) long survive a non-parasitic existence. Infection from swallowing expectoration must be looked upon as very important, for the people of this country defæcate and urinate in the open, and even infective matter from hospitals often finds its way into the dust. This infected dust is blown into the noses and throats of people and swallowed, often in a concentrated form with myriads of micro-organisms to the cubic centimetre. Apart from infective matter from without, other infective matter may also be swallowed from the mouth or throat of the individual in conditions of oral sepsis. Of infections acquired in these ways, the micro-organisms of sepsis, the typhoid bacillus, the pneumococcus, the cholera spirillum, the tubercle bacillus and the microbes of dysentery are the most frequent, and so far as enteric or small-bowel infections are concerned, those of sepsis and the typhoid bacillus are the most important, —more rarely the bacillus enteritidis from putrefying meat.

Infection from below, that is from the large intestine, has not been taken sufficiently into consideration. With a daily complete evacuation of the colon it is unlikely, but with constipation it is very probable, for when there is want of muscular tone in the large bowel fæcal matters gather in the cæcum or sigmoid. Fæcal accumulation in the latter place is a frequent cause of colon infections and need not be considered here, but in the cæcum it is a danger to the ileum, for only the ileo-cæcal valve and the vermiform appendix intervene. By distention, the ileo-cæcal valve may be forced, and infection then enter the ileum, or the vermiform appendix (a lymphoid structure which bears the same relation to the lower end of the digestive portion of the alimentary tract as the tonsils do to the upper end—the large intestine is almost purely excretory) in attempting to deal with the infective matter may itself become infected. (Appendicitis.) The chief infecting micro-organisms from below are those of sepsis, the bacillus coli and the para-colon bacillus.

In this way either from above or from below, infecting agents may reach the ileum and gain lodgement in the mucosa—helped in all probability by some superficial necrosis or abrasion. Finding favourable conditions, they multiply there and produce their poisons. This induces, first of all, physiological reaction on the part of the defenders—the lymph nodules, solitary and agminated. This may be effectual, and the individual never be aware that he has been saved from a severe local infection. On the other hand it is frequently insufficient, and sooner or later the toxins make their way past the defenders and reach the circulation. Then the patient feels out of sorts and suffers from languor and malaise, (all this in the so-called incubation period); but soon, the toxins entering the blood-stream in greater and greater amount, awaken the system to its danger, and then the true inflammatory reaction begins. This causes so much discomfort to the individual that he probably has to take to bed, and this directs our thoughts and anticipations towards "Enteric Fever" when the pathological reaction is continued long enough to arouse suspicion.

The local defenders by calling to their aid the system with its reserves of leucocytes (lymphocytes from lymphoid tissues —sufficient in subacute and chronic infections, and polymorphonuclears from bone marrow—essential in acute infections) may speedily deal with the local infection, in which case only mild fever for a few days results—often confused with malarial fever, or if it lasts long enough to be recognised, it may be called "abortive Typhoid or Enteric." In many cases this defensive effort is insufficient and recovery can only ensue at the sacrifice of portions of the intestinal mucosa,—the necrosed areas where the infecting microbes have lodged. This is a true ulcerative reaction, on the principle that it is "better that one member should perish than the whole body be cast into hell fire," and there we have the typical Enteric Fever. This is probably a truer explanation of the ulceration in Enteric than that it is caused directly by the micro-organism, for similar changes take place in the separation of a gangrenous area in a limb, and in the intestine, the ulcers left after sloughing always tend to heal if the ulcerative process has achieved its purpose. In other cases again, despite the ulcerative reaction, microbes cannot be prevented from entering the circulation. When this happens, the local reaction of the tissues may still continue, and repair at the site of invasion be accomplished, leaving those microbes that have entered the circulation to be dealt with separately. A clear way out for them is provided through the kidneys into the urine, and through the liver into the bile; many are trapped in the spleen or in the elaborate filter-system—the lymphoid tissues and lymph glands —and others find their way into some lonely lymph sac where they can be dealt with at leisure. As the microbes wander through the circulation, or on their way out, they may find some suitable place for lodgement and multiplication and secondary inflammatory reaction often occurs wherever they lodge. This perhaps explains the relapses of Enteric, and certainly explains the infective endocarditis, phlebitis, broncho-pneumonia, meningitis, arthritis, pleuritis, pericarditis, cholecystitis, pyelitis, &c., which often follow Enteric infections and which are called secondary inflammations. Lastly, from insufficiency of the local inflammatory reaction (lowered resistance) the microbes may invade and swamp the circulation—septicæmia—leaving the system little or no power to make a successful resistance. (See also the argument developed in Chapter VIII.)

Finally, we may recall the facts already stated, from the experience of the American Camps during the Spanish war, which indicate a very marked measure of immunity, as regards the incidence of Enteric Fever, exhibited by individuals who had previously suffered from attacks of Remittent and Continued Fevers and from bowel complaints (dysentery, diarrhœa and enteritis). Nothing very definite can be said at present on this subject as regards India, beyond the fact that the morbidity-rates recorded in the different geographical areas from Remittent and Continued Fevers* and from Dysentery are, frequently, highest where the Enteric rates are lowest. (See statements and maps in Chapter IV.) But it is precisely in these areas that all the conditions are most favourable to the prevalence of Malarial Fevers, of the existence of which there is no shadow of doubt, and it was one of the main contentions of the American Commissioners that true Malarial fevers were of the rarest occurrence in the U. S. Camps. When the statistics of individual regiments are examined it is sometimes found that those having the highest Enteric Fever rates have also rates above the average for Remittent and Continued Fevers and bowel complaints, as compared with those recorded for the other troops located in the same area; and this is to be expected, when we consider the special liability of young men and new arrivals to attacks of Malarial Fevers and of bowel derangements as well as to Enteric Fever. When, again, we examine the relative fatality of these diseases on the different age-periods, we find that while the death-rate from Enteric Fever is at its lowest at the age of 30 and upwards, the reverse is the case for Remittent Fevers, the mortality *per mille* of strength rising steadily with each age-period; as regards Dysentery, however, we do not get this definite contrast, the death-rate (1894—1899) at the period 20-30 years being ·81, while

* These fevers doubtless include various different pathological states; Malarial affections, the results of fatigue and exposure to sun and to sudden chills, of dietetic errors, and possibly influenza; it is notable that Simple Continued fever is, as a general rule, most prevalent in the extreme North West (continental area) and in the low-lying moist climate of Madras and Burma coasts, which is significant of the complexity of its etiology. (On the subject of the differentiation of Indian fevers, see Chap. IX and the Appendix to this Chapter.)

that for the ages 30 and upwards was ·65, the difference, while not being at all comparable with that exhibited by the Enteric rates, points rather to a similar age-liability as regards the two diseases (Chapter VIII.). That many cases of anomalous fever recorded as Remittent or Simple Continued are of truly Enteric nature there can be no doubt, but the widespread prevalence and abundance of true Malarial infection and of anomalous forms of fever, and the personal idiosyncrasies of the reporting agency, make it difficult to deduce satisfactory conclusions from the records available as to the extent of this error. Where the death-rates from both Enteric and Remittent Fevers are high, and also where they exhibit an inverse relationship, one may see in each instance a suggestion of failure to recognize the true nature of one or other of the diseases. But clearer light on this question will be obtained from the consideration of the relative recorded seasonal incidence of these diseases which will be dealt with in the next chapter. It remains to be noted that the results of the Commissioners appointed to enquire into the etiological connexion between Dysentery and Enteric Fever among the troops in South Africa during the Boer war, were definitely unfavourable to the view of any "specific" etiological unity of the two disorders ; we shall examine the facts in this connexion from the epidemiological side, when we deal with the question of the prevalence of Enteric Fever among natives (Chapter VIII.). The view generally taken on the subject is that any connexion between Dysentery and Diarrhœa and Enteric Fever must be held to be more or less indirect, and to take the form of a predisposing influence, subject to the generally prevailing conditions which favour equally the prevalence of all specific bowel diseases. We shall, however, see that there are considerations of weight which may compel us to revise our conceptions in the light of the etiological affinities of these diseases. The reaction on the part of the tissues of the host to the stimulus of one number of a group of (probably) identical origin and having intimate biological affinities, may result in affording a measure of resistance to the attack of an allied form, quite apart from any assumption of the possibility of the transmutation of species.

The reader is recommended to turn to the Summary of the Etiology at the conclusion of Chapter VIII., which supplements the views which have now been set forth, and amplifies them by considerations derived from a study of the conditions affecting the natives of India.

APPENDIX TO CHAPTER III.

On the Differential Diagnosis of Tropical Fevers: Classification and Orientation: Practical Methods.

The following Memorandum was drawn up by Major D. W. Sutherland, I.M.S., Professor of Medicine at the Lahore Medical College, in the form of a letter to the writer, who deems it too valuable to withhold it from the wider sphere of influence which its publication will command. The subject needs no commendation for its importance in its direct application to the solution of the dominant problems of tropical medicine; its treatment here may be safely left to make its own appeal.

The following postulates may be assumed in any given case of fever :—

1. The "cause" must either be infective or non-infective.
2. With our present knowledge an infective cause is always the more likely.
3. If the cause is infective, a parasite of some one or other sort must be present somewhere in relation to the inside or outside of the body, and, in all probablity, is discoverable. Such parasite must be either—
   (*a*) Animal (amœba, piroplasma, Leishman-Donovan body, trypanosome, worm embryo or worm) or,
   (*b*) Vegetable (coccus, bacillus, spirillum, or fungus).
4. The infection must be either (*a*) of the general circulation; (*b*) of the spleen or lymph circulation; (*c*) a local infection of some mucous surface of entrance into, or exit from, the body; (*d*) an intoxication from without.
5. If it be an infection of the general circulation it must be possible to find the parasite, or evidence of its presence, in the circulating blood.
6. If it be a spleen or lymph infection, it must be possible to find the parasite, or evidence of its presence, in the spleen or in the lymph circulation.
7. If it be a local infection of some surface of entrance or exit, the general circulation should show evidence of the entry of toxins into it from some one or other source; the parasite will probably excite clinical signs to indicate where it is located, and the parasite itself will be present in some one or more excretions of the body.
8. A negative finding on all these points would imply that the cause of the fever is non-infective.

Methods of procedure :—

(*a*) Is it a general infection?

By general infection is meant infection of the circulating blood. To prove it a general infection, the parasite must be found in the circulation, or evidence must be obtained of its having been there.

Determine by repeated examinations of the peripheral circulation at intervals in the course of the fever, and by night and day to exclude filariæ. examine blood obtained by making (1) specimen of fresh blood, ringing the slip with vaseline, and examining on a warm stage, with or without the addition of a stain (polychrome blue). (2) Thin and thick film preparations (decolorizing the red cells if necessary) and staining with Leishman, Romanowsky, &c.

The discovery of the parasite settles the diagnosis, for then all that is required is to identify the parasite to give a name to the infection. It may be the hæmamœba of malaria, Leishman-Donovan body, piroplasma, spirochæte of relapsing fever, one or other trypanosome, one or other filaria embryo, one or other form of coccus, bacillus, spirillum or fungus. A negative finding is inconclusive, for (1) the parasite may not be in the circulation at the time, as in case of filarial embryos which only appear during sleep; or (2) the parasites may be few in number, and in any case one can hardly expect that a single drop of blood will always contain a parasite. Examination during the hours of sleep will settle the first difficulty, and repeated examinations in the course of the case may settle the second. A good plan, however, is to draw off a large quantity of blood, citrate it, and keep it in a sealed tube in the incubator at the body temperature for some days, when multiplication of the parasites, if present, makes their recognition easy. Sometimes the parasite can only be found by making cultures from the blood, or by making inoculations into susceptible animals.

The next best thing to finding the parasite in the circulation is to gain evidence of its having been there. All parasites do not leave traces behind them, but the malarial parasite (and perhaps the piroplasma and Leishman-Donovan parasite) leaves signs of its presence in the shape of broken-up red cells and free pigment, which are taken up by leucocytes. The spirochæte of relapsing fever also leaves behind it in the blood, in the apyrexial periods, small coccus-like bodies. The discovery of broken-up red cells, free pigment and pigmented leucocytes in the circulation is generally good evidence of malaria and may suffice for a diagnosis even in the absence of the parasite. Similarly small coccal bodies in the blood after a period of pyrexia suggest an attack of relapsing fever. In a general infection there may also be leucocytosis, a relative increase of one or other variety of leucocyte, and increased activity of those leucocytes which are phagocytes; but none of these signs are distinctive for they tend to occur in spleen and lymph infections, and in local infections as well, and they may also arise from purely toxic causes.

When the above methods fail to reveal a parasite, or signs of its presence, in the circulating blood, we are justified in assuming that the infection is not a septicæmia.

(*b*) Is it a spleen, or lymph infection?

Few microbes can live long in the circuating blood and they usually take refuge in the spleen or in the backwaters of the circulation—the lymph stream. Probably they arrive at these situations from compulsion as well as from any possible choice they may exercise, for the spleen, lymphoid tissues and lymph glands are the great filtering media of the blood.

If the parasite is in the spleen, or in the lymph circulation, its toxins must of necessity pass into the blood, and evidence of this will be found in the way of leucocytosis or lymphocytosis. The latter is specially distinctive of spleen and lymph infections, particularly when the lymphocyte increase is of the large mononuclear variety. In the absence of parasites a relative increase of the large mononuclears may be taken to mean spleen infection—probably malaria or the infection associated with the Leishman-Donovan body—although a less marked increase is also seen in local infections like enteric and tuberculosis, and perhaps syphilis, where lymphoid tissues are involved. The large mononuclear is the actively phagocytic state of the ordinary lymphocyte, and for that reason its increase is always suggestive of infection that is being dealt with by the lymphoid structures of the body.

When the parasite is located in the spleen, the organ will show signs of its presence by enlargement, hence splenomegaly apart from local disease will always be suggestive and may call for spleen puncture. If the parasite is in the spleen it will be living in the splenic sinuses among the cells of the spleen pulp. To determine if this be so, make a spleen puncture and examine as in the case of peripheral blood, making sealed tubes, cultures and inoculations into animals, if necessary. The discovery of the parasite by any of these methods settles the diagnosis, and if the former blood examination has been negative the parasite found will probably be the malaria parasite or the Leishman-Donovan body, but microbes from local infections which have slipped through into the circulation may also be caught, especially the bacilli of anthrax and typhoid, and the micrococcus of Malta fever. In the absence of parasites one should look for evidence of spleen irritation as shown by the presence of macrophages, for these are always suggestive of spleen infection. Absence of both parasites and macrophages implies that there is no infection of the spleen.

When the parasite is in the lymph circulation it is likely to be resting (or held up) in lymphoid tissue, lymph glands or in one or other lymph sac, but evidence of the entry of toxins into the circulation will have been obtained by finding leucocytosis or lymphocytosis in the blood examination. In the case of some lymphoid tissues, as the tonsil and vermiform appendix, and in the case of superficial lymph glands, the parasite will in all probability give signs of its presence by enlargement of one or other structure, and, in the case of most lymph sacs, by effusion. If this be so, puncture of the tonsil or of the swollen gland is likely to settle the diagnosis by revealing the parasite. In other lymphoid tissues, *e.g.*, perivascular lymph nodules, the lymph nodules about the respiratory-tube, and the Peyer's patches and solitary glands of the intestine, any enlargement present is not clinically evident, and the fact that they are infected is only revealed by other methods. For that reason these will be discussed with the local infections. The same holds true of the deep lymph glands; mesenteric, retro-peritoneal, bronchial, mediastinal, &c. In the case of lymph sacs, with the exception of the meningeal, there are physical signs of effusion and the exploring needle often quickly makes a diagnosis possible by revealing the parasite, while if the effusion is sterile, the agglutination test with a culture of the tubercle bacillus, or the intra-peritoneal injection of 15 or 20 c. c. of the effusion into a guinea-pig, demonstrates the cause to have been tuberculosis within a few weeks. In all doubtful cases, where the blood examination shows leucocytosis or lymphocytosis, where there are no physical signs, and where spleen puncture is negative, lumbar puncture should be made to see if there be effusion into the meningeal lymph sac. Signs of exudation (as distinct from transudation) are positive, and the discovery of the parasite completes the diagnosis. When the exudate is sterile, the case is likely to be one of tuberculosis, and confirmation is to be sought by the agglutination test and by inoculations into guinea-pigs.

Absence of signs of enlargement of lymphoid structures, and of effusion into serous sacs, and negative results from lumbar puncture, imply that there is not a lymph infection, with the possible exception of infection of the visceral lymphoid tissues or of the deep lymph glands. The three infections most likely to occur in these situations are Enteric fever, Malta fever and acute general tuberculosis, and further evidence can be gained as to these by the agglutination and sedimentation tests, and by the diazo-reaction. A positive diazo-reaction might imply either Enteric fever or acute general tuberculosis, but positive agglutination and sedimentation reactions for Enteric and Malta fevers are distinctive, under proper conditions of the technique employed.

By this time the field of enquiry has been narrowed down—a diagnosis has already been made, or negative results, so far, may have enabled us to exclude malaria, piroplasmosis, Leishman-Donovan infection, filariasis, trypanosomiasis, relapsing fever, septic infection, &c., with an approach to certainty; and possibly Enteric fever, Malta fever and acute general tuberculosis as well.

(*c*) Is it a local infection ?

As a general rule local infections cause well marked symptoms in the way of pain and disturbance of function and evident physical signs, but when in the bowel, deep down in the lung, or in the biliary, urinary or Fallopian passages, the physical signs may be so slight that they are overlooked. These secret local infections are generally associated with the micro-organisms of suppuration, with bacilli of the typhoid, colon, or paracolon groups, or with the tubercle bacillus, and unless borne in mind they will often pass unrecognised. Septic throat infections are liable to be overlooked and the resulting fever is often attributed to "malaria" simply because the throat was never examined.

The blood examination usually gives evidence of these infections, and a leucocytosis or relative increase of the lymphocytes or of the polymorphonuclears in the circulation, with absence of parasites in the peripheral blood, spleen or lymph, is always suggestive. A lymphocytosis points to tuberculosis or to a bowel infection by one of the typhoid or allied groups, and a polymorphonuclearcytosis to a local septic infection. The diazo-reaction may give evidence about the first two, the agglutination and sedimentation tests about the second, while the finding of peptone or albumose in the urine may indicate the third. A lymphocyte increase is of less value in diagnosing local infections than an increase of the polymorphonuclears, and calls for the diazo-reaction, the agglutination and sedimentation tests, and the search for tubercles in the choroid with the ophthalmoscope to clear up the issues. Increase of the polymorphonuclears on the other hand is distinctive, for it means local septic infection somewhere, and should send the observer back from the microscope to the patient to look more carefully for it. The conditions which should be examined for, one by one, are :—oral sepsis, sore-throat, appendicitis, abscess of the liver, subphrenic abscess, infective cholangitis, infective endocarditis, phlebitis, empyema, deep-seated pneumonia, abscess of lung, suppurative osteo-myelitis, suppurative periostitis, pyelitis, salpingitis, otitis media, mastoiditis, thrombosis of the lateral sinus, abscess of brain, cerebro-spinal meningitis, &c. With a polymorphonuclear increase in the blood, more thorough clinical examination will generally reveal the local mischief and settle the diagnosis, although the particular infecting microbe may not be determined until the necessary operation is performed.

If the diazo-reaction, the serum agglutination and sedimentation tests have given positive reactions and have indicated the nature of the infecting microbe the diagnosis should be confirmed by microscopic examination of the sputum, fæces and urine as the case may be, and cultures should be made and animals inoculated if necessary. The infecting micro-organism can generally be distinguished from others by making the agglutination and sedimentation reactions with the patient's blood, due regard being paid to the probability of a mixed infection (symbiosis).

Having isolated the infecting agent in the above ways it should be cultivated, or kept in sealed tubes if the former be impossible, and subsequently used for prognostic purposes by testing, from time to time during the illness, the agglutinating power of the patient's blood and its bactericidal and phagocytic powers.

Apart from the side-room (laboratory) research, valuable information will be obtained from day to day at the bedside by watching the course of the disease, and the effects of treatment. The daily physical examination may reveal some local lesion which at first was not apparent; the time test may bring out distinctive rashes and show the affection to be one of the eruptive fevers, or may reveal characteristic features which identify the condition; the fever chart may become typical or the therapeutic quinine test abolish the fever. A consistently slow pulse will point to typhoid, the *tâche cérébrale* to typhoid or acute general tuberculosis, and so on, through all the established diagnostic criteria.

If such a method of procedure be followed as a routine in doubtful cases, few will remain over to be returned as Simple Continued Fever, Remittent Fever, &c., terms which now fill the Returns. On the other hand many slight cases of fever will occur where little or no information is got from the side-room examinations, and where recovery takes place before a scientific diagnosis has been made. In these cases it is hard to say what the fever should be called, and as they are generally associated with a little gastric, intestinal, bronchial, or uterine catarrh, it is best to return them under those heads. It would be well to regard every case of fever as having its origin and being in some infection or toxic process, *i.e.*, in the reaction of the tissue cells thereto, and it is safer to conclude that heat and "chill" act only as predisposing factors.

In the above sketch, little has been said about toxic causes of fever as apart from infective causes, but doubtless toxic substances produced by intestinal and other parasites, are capable of causing fever, and in most cases in India a search for ova in the stools, urine and sputum should be made. There is also the condition called "Fermentation fever," a subject to which Burdon-Sanderson was the first to direct attention, and which arises from the absorption of digestive ferments, fibrin ferment, extracts of fresh tissues, &c., and which is seen with gastro-intestinal disturbance, particularly in children, and after bruises, hæmorrhages, operations and the passage of a sound or catheter. It may also be noted that, as in the case of Tuberculin, Professor Krehlhas obtained a pyrogenetic albumose from cultivations of *B. coli commune.*

CHAPTER IV.

Epidemiology (I.).

Local and Seasonal Incidence.

In this and the two following chapters, the main epidemiological facts will be presented; and, first, we shall deal with the local and seasonal incidence of the disease in cantonments under ordinary peace conditions; in the next place, we shall survey the evidence derived from the experiences of camps (including route-marching) and campaigns; and, lastly, the incidence on the different arms of the service, on corps units, and on officers, women and children will be discussed.

We have already (Chapter II.) examined the evidence regarding the course and rise of the disease since its recognition in this country, and in the statement given, the more salient features of the contrast in the local incidence on the different Presidencies and (since 1895) Commands have been indicated. With more or less considerable fluctuations from year to year, the recorded rates have steadily risen in all the Commands up to, and including, the year 1898, to fall during the next triennium (1899–1901) to the point attained 15 years previously (1887), and to resume the upward trend during the last three years (1902–1904). These movements, however, have not been displayed in equal degree in the different areas, but are distinctly more marked where the disease has always been most prevalent. From 1884 to 1898 the recorded rise in the morbidity and mortality in the Bengal and Punjab Commands taken together was equal to just over 100 *per cent* (from 15·3 and 4·24 to 33·2 and 9·81 *per mille* of strength, respectively); in the Bombay Command the corresponding rates were 10·3 and 3·24 against 23·6 and 6·4; while in Madras the recorded rates rose from 10·2 and 2·61 to 14·1 and 3·39, the proportional increase here being less than half that displayed elsewhere.

TABLE XIX.

Local Incidence on Presidencies during last 25 years.

Period.	Bengal, including Punjab.		Bombay.		Madras.	
	Ratio per 1,000.		Ratio per 1,000.		Ratio per 1,000.	
	Cases.	Deaths.	Cases.	Deaths.	Cases.	Deaths.
1879—1883	8·4	3·30	5·5	2·75	3·6	1·67
1884—1888	15·3	4·24	10·3	3·24	10·2	2·61
1889—1893	25·3	6·50	15·3	4·41	11·9	3·50
1894—1898	33·2	9·81	23·6	6·47	14·1	3·39
1899—1901	17·2	4·61	19·8	4·95	10·2	3·14
1902—1904	20·1	4·39	21·1	4·67	11·9	2·33

It is unnecessary to dwell upon the facts here disclosed as it is preferable to deal with the smaller geographical areas under similar climatic conditions into which the Commands may be divided. But while leaving the broader features of the local incidence to speak for themselves it must be mentioned that the contrasts here displayed between Northern and Southern (Peninsular) India generally would be much more marked but for the following circumstances ; the large station of Quetta was transferred from the Bengal Command in 1895 to that of Bombay, and severe outbreaks of Enteric Fever occurred in this cantonment in the years 1896, 1898 and 1900, in which no less than 501 cases were recorded, a number large enough to affect materially the rate for the whole Command, while reducing that for Bengal. Then as regards Madras we have to take account of the effect on the rates of the experience of two stations, Secunderabad (Deccan) and Bangalore (Mysore plateau), from which alone 1,856 cases were reported in the period 1884 to 1903 out of a total, for the whole Command, of 2,852. If these circumstances be duly appraised, it will be found that the great increase shown in the recorded rates, which commenced with a bound in 1889, is almost confined to the Northern "continental" area (or, more strictly, to the endemic area), where the highest point was attained with another bound in 1897–98, synchronous with the extensive operations in the field on and beyond the North-West Frontier ;

and it is in this area as a whole that the decrease was shown in disproportionate measure in 1889–1901, subsequent to the campaign and during the period of the Boer War, when the supply of drafts and reliefs was almost suspended. It may be added that whenever the rates are seen to rise suddenly to an extent beyond the usual increment, the fact may be associated with more or less extensive active field service, as, notably, in 1878–1880 (Afghan war), in 1884–1885 (Burma), 1895 (Waziristan and Chitral) and 1897–98 (North-West Frontier). It should be noted that the rates now referred to do not purport to include the disease acquired during service in the field. No considerable expeditions have been undertaken since the last named, and two other influences must be associated with this fact in studying the subsequent course of the disease; *viz.*, the suspension of the supply of drafts and reliefs during the Boer War, and then, when the supply was resumed from the winter of 1901–1902, a large majority of the men arriving in the country came from South Africa, or other parts of the Empire outside the United Kingdom. We shall see that the age-factor and that of previous experience of the disease have very definite effects on both its local and seasonal incidence.

The position to which we have so far attained may be rendered clearer by the following statement which is based on the returns for the 8-year period 1895–1902. In this we differentiate between four different bodies of men each located in an environment having special physical features that mark it off from the rest; first, the seaport garrisons, six in number; next, the Bombay and Madras Commands, excluding seven stations that are situated in inland and upland areas that have close affinities in their physical characters with those of continental India; then come these seven selected stations, *viz.*, Quetta, Poona, Nasirabad, Deesa, and Mhow in the Bombay Command, and Secunderabad and Bangalore in that of Madras; lastly, we take the rest of India, excluding the above areas but including the whole of the Northern and more or less continental area (see next page).

These results require no comment, after what has been said, beyond the remark that a comparison of the incidence of other specific bowel complaints (Cholera, Dysentery and Diarrhœa) does not exhibit this striking contrast; for example, the mean ratios for the past five years for Cholera are the same in the seaports as for the rest of India; the Dysentery rates are actually higher in the former, and only those for Diarrhœa are

TABLE XX.

Enteric Fever in broadly-contrasted Geographical areas.
1895–1902.

	Locality.	Aggregate strength for period.	(Actuals.)		Ratios per 1,000.	
			Cases.	Deaths.	Cases	Deaths.
	1. Six seaports	47,892	296	101	6·3	2·11
	2. Bombay and Madras Commands, excluding 7 selected stations	128,518	1,388	399	10·8	3·10
Endemic Area proper.	3. The 7 selected stations (Bombay and Madras Commands).	88,183	2,497	624	28·3	7·08
Endemic Area proper.	4. India (Northern), excluding all above.	262,686	8,346	2,202	31·7	8·38

lower, but in nothing like the same proportion as in the case of Enteric Fever. A reference was made to this point in the preceding chapter. The contrast in the results for the oceanic and true peninsular areas (1 and 2) and those for the continental or endemic areas (3 and 4) is very striking.

In coming now to closer terms with the local distribution of Enteric Fever, it should be explained that the whole area occupied has been sub-divided up into twelve parts on the basis of the geographical and climatological features which are more or less special to, and distinctive of, each ; the names of these groups will convey a sufficiently clear idea of their position and climatic characters in the light of the general account of the environment already sketched (Chapter III.) and of the charts showing the chief meteorological conditions. Dealing, first, with the period of steadily increasing and maximum incidence and avoiding for the present the disturbing influence of subsequent events, the following statement exhibits the position in its broad essential aspects, the rates for Malarial and other fevers being given for comparison.

It will be seen that while Enteric Fever is recorded as occurring in all the groups occupied by the troops, there is a very marked contrast in its relative distribution ; the rates yielded by all the Northern and Inland groups, including the Hill stations (V., VI., VII., VIII., IX. and XII*a*) stand out clearly from the rest and indicate the sites of election of the disease,

TABLE XXI.

Geographical distribution of Enteric and Other Fevers. Period 1889–1898 (10 *years*).

		Ratios per 1,000 of the average strength.											
		I.	II.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XIIa.	XIIb.	
		Burma Coast and Bay Islands.	Burma Inland.	Bengal and Orissa.	Gangetic Plain and Chutia Nagpur.	Upper Sub-Himalaya.	N.-W. Frontier, Indus Valley and N.-W. Rajputana.	S. E. Rajputana, Central India and Gujarat.	Deccan.	Western Coast.	Southern India.	Hill Stations.	Hill Convalescent Depôts and Sanataria.	INDIA.
Enteric Fever ...	A.	9 3	5·0	11·6	31·2	29·4	19·6	32·3	20·2	7·6	15·4	33·9	14·8	24·6
	D.	3·67	2·0	3·22	7·82	8·15	7·22	9·48	5·15	3·15	3·27	6·92	50·1	6·54
Simple Continued Fever	A.	86·4	48·7	31·2	44·2	41·7	35·3	43 1	32·7	78·9	58·3	22·8	15·5	39·0
	D.	..	·04	...	...	·01	·02	..	·02	·21	·03	·01	...	·02
Remittent Fever	A.	6·8	26·0	22·1	11·3	10·1	42·5	11·2	7·3	7·7	7·4	9·2	8·2	14·2
	D.	·59	1·25	·48	·15	·49	2·19	·24	·11	·27	·14	·21	·6	·51
Intermittent Fever ...	A.	178·9	387·1	404·9	226·4	458·3	731·8	482·9	251·1	157·4	139·9	252·4	285·7	359·8

Endemic Area of Enteric Fever (Groups V.–IX.).

OTE.—Group III (Assam) is not included, as not being occupied continuously by any considerable body of European troops.

comprising as a whole what we shall designate the endemic area. Group XI., though included in Southern India, is situated on the Mysore plateau and has general close affinities (physical and climatic) with Group IX., the Deccan tableland. If now the map is studied in the light afforded by the account previously given of the physical characteristics of the environment, certain broad but definite associations emerge clearly between these characteristics and the incidence of the disease. Where, indeed, the correspondence is not exactly defined we shall be able to discover the operation of modifying factors, *e.g.*, occasional outbreaks amounting to epidemics, in stations where the strength is comparatively small, which enhance unduly the rates for a ten-year period; and also the influence of aggregation, traffic, &c. The chief physical features of the endemic area have been so fully detailed that it is unnecessary to re-emphasize them at this point; moreover, the charts displaying the seasonal incidence will serve to recall the essential facts. It must be remembered that we are dealing with returns from isolated and more or less widely scattered communities of very varying size, and not from a more or less dense and equally distributed population such as is ordinarily found in Europe, and this fact renders the definite correspondence of the incidence with the local physical conditions the more striking, in view of the fluctuations of disease prevalence to which the constitution of the communities with which we have to deal are necessarily liable. It is, therefore, necessary to show that the incidence on individual stations is strictly in accord with that of the inclusive areas; the statement which follows gives the decennial rates reported from the largest cantonments (those having an average strength of over 1,000 men), the Roman numerals indicating the geographical groups to which they belong. In an Appendix to this chapter, a similar list is given which includes all the stations where troops are located and which brings out the same essential facts as to local incidence. (Appendix I.)

In this list we have stations representing all the geographical areas, and each of which has been occupied constantly by a large number of troops for a period sufficiently long to obviate fallacy from occasional and temporary influences, and the contrast displayed in the extent of the sickness and mortality is very striking and conforms to their geographical position. One or two considerations may be adduced to reinforce the demonstration, and we shall deal with data referring to two periods,

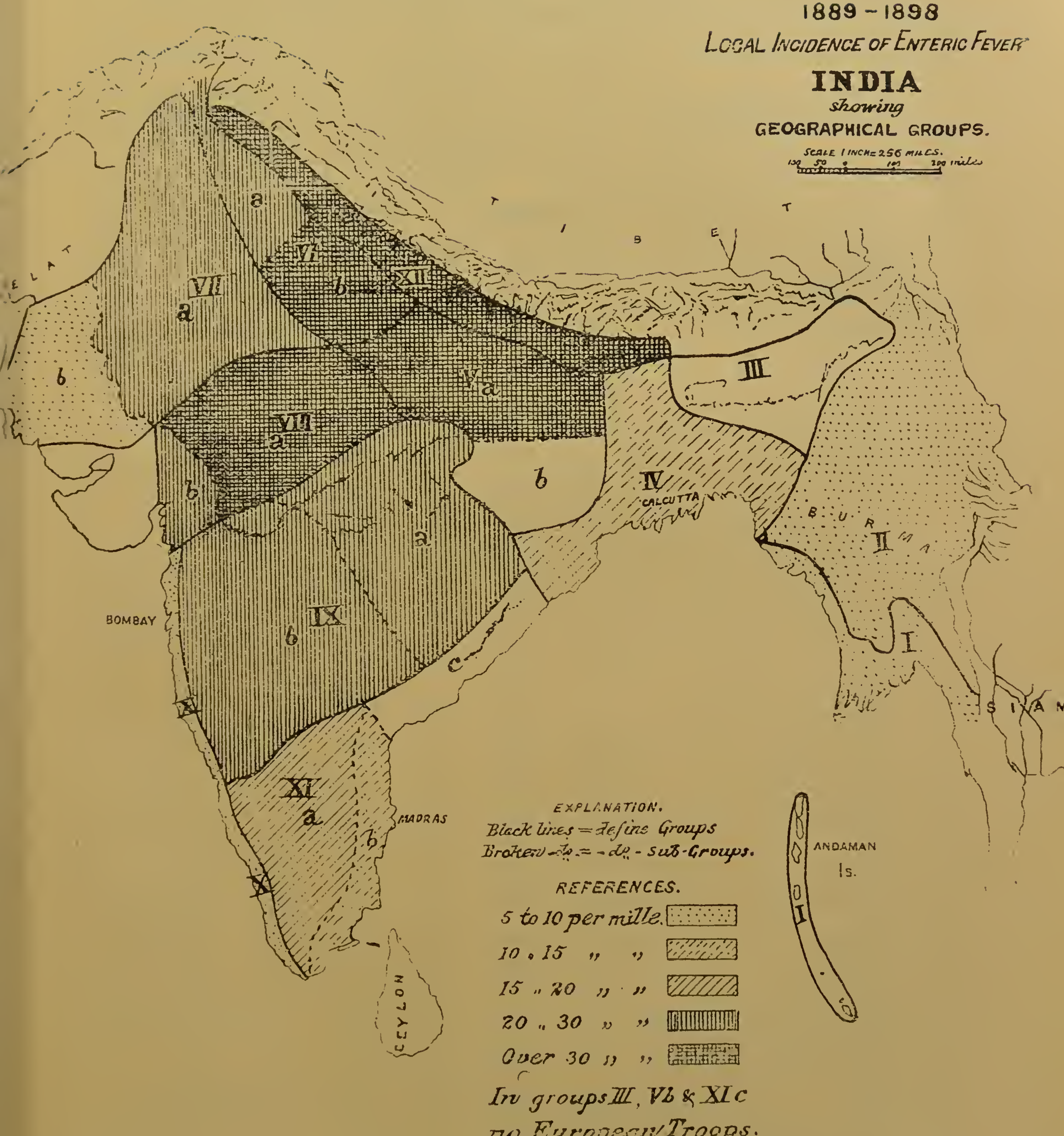

1889 - 1898
LOCAL INCIDENCE OF ENTERIC FEVER
INDIA
showing
GEOGRAPHICAL GROUPS.
T I B E T
BOMBAY
CALCUTTA
MADRAS
CEYLON
ANDAMAN Is.
B U R M A
S I A M
EXPLANATION.
Black lines = define Groups
Broken do. = do. - Sub-Groups.
REFERENCES.
5 to 10 per mille.
10 „ 15 „ „
15 „ 20 „ „
20 „ 30 „ „
Over 30 „ „
In groups III, Vb & XI c
no European Troops.

TABLE XXII.

Enteric Fever in Stations with strengths of upwards of 1,000 men, in order of highest admission-rates.

	STATIONS. (Strength over 1,000.)	1889–1898. Ratios per 1,000.		Geographical Groups.
		Admissions.	Deaths.	
1	Agra	48·6	13·60	VIII.
2	Bareilly	40·6	10·12	VI.
3	Lucknow	40·2	9·50	V.
4	Chakrata	36·8	7·99	XII*a*.
5	Ranikhet	36·5	6·13	XII*a*.
6	Meerut	35·6	10·23	VI.
7	Mhow	35·1	8·52	VIII.
8	Allahabad	34·6	9·36	V.
9	Sialkot	33·0	7·27	VI.
10	Umballa	31·1	8·11	VI.
11	Quetta	30·7	6·99	XII*a*.
12	Peshawar	30·1	12·89	VII.
13	Rawal Pindi	28·6	7·88	VI.
14	Secunderabad	25·2	6·03	IX.
15	Bangalore	20·3	3·90	XI.
16	Poona	18·1	5·02	IX.
17	Kamptee	12·2	3·60	IX.
18	Rangoon	9·6	3·09	I.
19	Wellington	8·8	2·75	XII*b*.
20	Fort Dufferin (Mandalay) ...	6·1	2·16	II.
21	Fort William (Calcutta) ...	5·4	1·73	IV.
22	Aden ...	4·9	2·45	Seaport.
23	Colaba (Bombay) ...	4·2	1·71	X.
24	Belgaum	2·9	·66	IX.

one (1891–1900) when the disease was at its highest prevalence; the other (1901–1903) including the temporary decline in incidence.

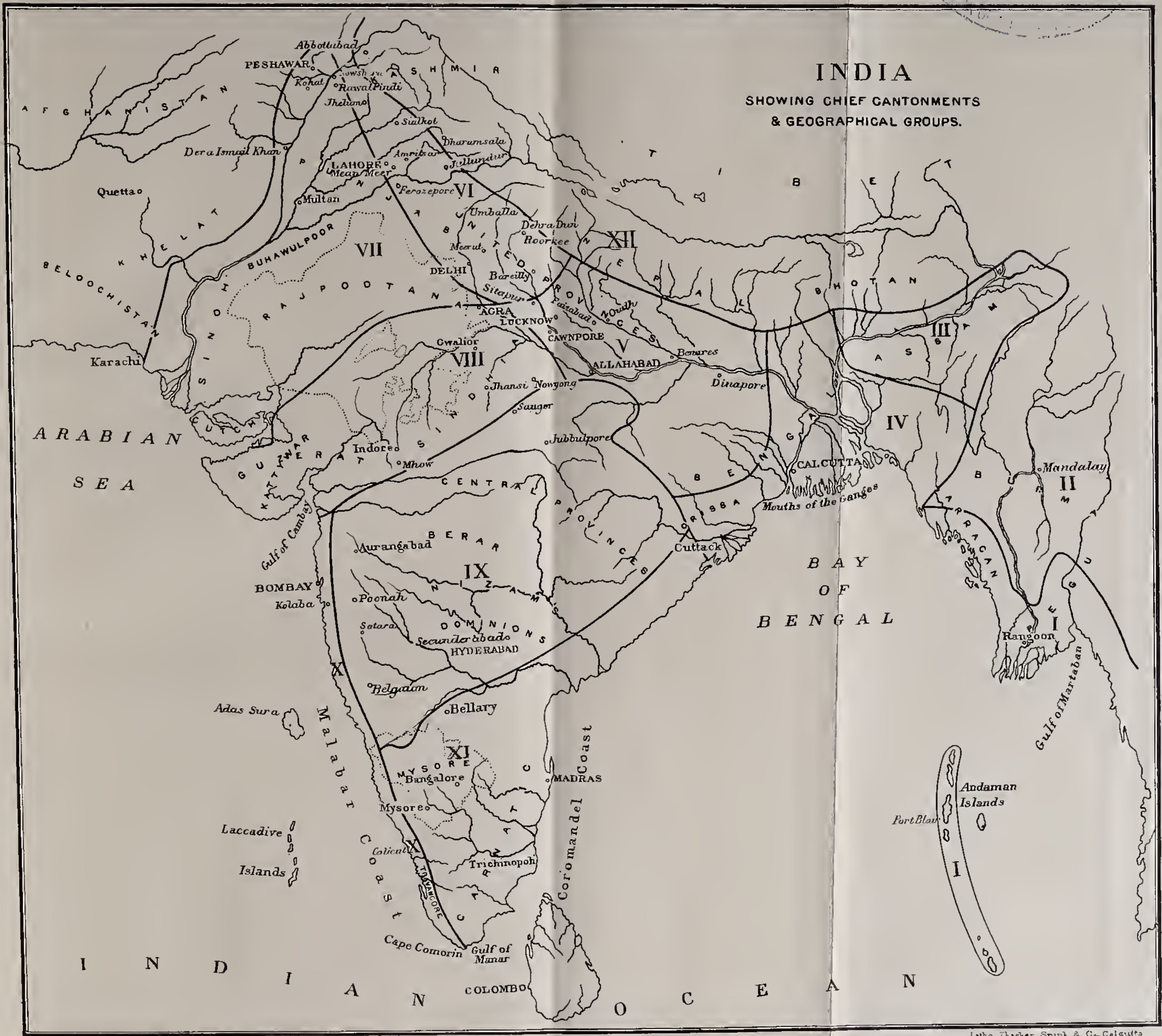
In the former (decade) there were in all 16,501 cases and 4,404 deaths reported from Enteric Fever from the 106 stations occupied by the forces of all arms, an average strength of 68,224 men, but no less than 12,090 of the total cases (73·2 *per cent*) and 3,069 of the total deaths (70 *per cent*) occurred in 36 stations with an average strength of 38,263 men, equal to 56 *per cent* of the whole army. In the latter period (triennium) the total number of cases reported in all India was 3,172, and of deaths 757, the average strength exposed being 63,941; but 2,405 (75 *per cent*) and 449 (59 *per cent*) of the admissions and deaths, respectively, occurred in 33 stations having an average aggregate strength of 35,906, which is but 56 *per cent* of the total force. The stations selected are, of course, those in which the disease was most prevalent, and it may be noted that they coincide with scarce an exception in both periods, for confirmation of which statement the Station Table, given in the Appendix, should be consulted.

Again, in order to mark down the chief endemic centres, we may take the cantonments from which 50 cases and upwards were reported during the last two years of the record, and during the two years of greatest prevalence.

1903.	A.	D.	1904.	A.	D.
1. Lucknow	94	12	1. Lucknow	117	17
2. Meerut	100	23	2. Meerut	101	22
3. Umballa	107	21	3 Umballa	105	24
4. Rawal Pindi	59	12	4. Rawal Pindi	84	17
5. Peshawar	55	16	5. Secunderabad	71	15
6. Nasirabad	82	16	6. Bangalore	73	6
7. Mhow	75	12	7. Quetta	71	2
8. Poona—Kirkee ..	79	19	8. Poona—Kirkee ...	100	18
	651	131		722	121
R. *per mille* of strength ...	40·2	8·0	R. *per mille* of strength ...	36·3	6·08
Ditto for rest of India ..	13·5	3·0	Ditto for rest of India ...	13·3	2·9

1897.		A.	D.	1898.		A.	D.
1.	Lucknow	122	30	1.	Lucknow	174	53
2.	Meerut	97	38	2.	Meerut	78	19
3.	Umballa	138	33	3.	Umballa	67	25
4.	Rawal Pindi	95	23	4.	Rawal Pindi	123	26
5.	Peshawar	87	53	5.	Peshawar	102	48
6.	Agra	181	49	6.	Agra	88	20
7.	Jhansi	63	17	7.	Mhow	76	20
8.	Mhow	81	28	8.	Bangalore	57	8
9.	Secunderabad	95	23	9.	Ranikhet	57	10
10.	Bangalore	67	12	10.	Chakrata	72	7
11.	Chakrata	54	6	11.	Quetta	232	75
12.	Dagshai	76	7				
13.	Cherat	80	21				
14.	Quetta	52	11				
		1,288	351			1,126	311
	R. *per mille* of strength ...	55·0	14·9		R. *per mille* of strength ...	58·7	16·20
	Ditto, rest of India ...	20·6	5·89		Ditto, for rest of India ...	28·3	7·79

In 1903, there were altogether 1,384 cases and 295 deaths, on a total strength of 70,445 ; but no less than 651 cases and 131 deaths occurred in the eight stations cited, having an aggregate strength of 16,179 ; the ratios *per mille* were thus for the eight stations in question, 40·2 and 8·0, against 13·5 and 3·0, respectively, for the rest of India. In 1904, the total number of cases was 1,368 and of deaths 265, on a strength of 68,224, but 722 of the cases and 121 of the deaths were reported from the eight stations in the list, the aggregate strength of which was 19,875 ; the ratios *per mille* were therefore 36·3 and 6·08 for the latter group as compared with 13·3 and 2·9, respectively, for the rest of India. It will be seen that five of the eight stations appear in this "black list" in both years, but Peshawar, Nasirabad, and Mhow only just escape inclusion in that of 1904, and the same is


INDIA
SHOWING CHIEF CANTONMENTS
& GEOGRAPHICAL GROUPS.
AFGHANISTAN
BELOOCHISTAN
KHELAT
PESHAWAR
Abbottabad
Kohat
Rawal Pindi
Jhelum
Sialkot
Dharmsala
Dera Ismail Khan
LAHORE
Mean Meer
Amritsar
Jullundur
Quetta
Multan
Ferozepore
Umballa
Dehra Dun
Roorkee
Meerut
DELHI
Bareilly
Sitapur
AGRA
LUCKNOW
Faizabad
Oudh
CAWNPORE
ALLAHABAD
Benares
Dinapore
Gwalior
Jhansi
Nowgong
Saugor
Jubbulpore
Indore
Mhow
BUHAWULPOOR
RAJPOOTANA
SINDH
PUNJAB
UNITED PROVINCES
SINDHIA
CUTCH
GUZERAT
KATTIWAR
Karachi
ARABIAN
SEA
TIBET
NEPAL
BHOTAN
ASSAM
BENGAL
CALCUTTA
Mouths of the Ganges
ORISSA
Cuttack
CENTRAL PROVINCES
BERAR
Aurangabad
NIZAM'S DOMINIONS
Secunderabad
HYDERABAD
BOMBAY
Kolaba
Poonah
Satara
Belgaum
Bellary
Gulf of Cambay
Adas Sura
Malabar Coast
MYSORE
Bangalore
Mysore
MADRAS
Coromandel Coast
CARNATIC
Trichinopoli
Calicut
TRAVANCORE
Cape Comorin
Gulf of Manar
COLOMBO
Laccadive
Islands
BAY
OF
BENGAL
BURMA
Mandalay
ARRACAN
PEGU
Rangoon
Gulf of Martaban
Andaman
Islands
Port Blair
INDIAN OCEAN
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
Litho. Thacker Spink & Co. Calcutta

true of Secunderabad, Quetta and Bangalore, as regards that of 1903. The results in 1897–1898 are very similar; thus fully half the morbidity and mortality falls upon this small number of stations in which only about 28 *per cent* of the total strength is exposed.

All the foregoing facts indicate a definite localization—endemicity—of the disease in certain places which are included in certain well-marked geographical areas. Further, it will be seen that the rates fluctuate to a large extent from year to year in individual stations whether within or without the endemic list, but that in those within the endemic area the disease is always present at some period of the year, whereas elsewhere it is not infrequently absent or unreported, or occurs in sporadic cases at long intervals, with, here or there, a more or less serious outbreak which does not recur for a considerable time. In 1897–98, when the disease had attained its maximum prevalence, no case was reported from 33 stations and only a single case from each of 26 other stations. In 1900–1902, a period of comparatively low prevalence, 72 stations were in the former happy case and 44 in the latter, thus :—

		No. of Stations from which no case was reported.	No. of Stations from which only 1 case was reported.
Period of maximum prevalence ...	1897	15	16
	1898	18	10
Low prevalence	1900	27	14
	1901	24	19
	1902	21	11

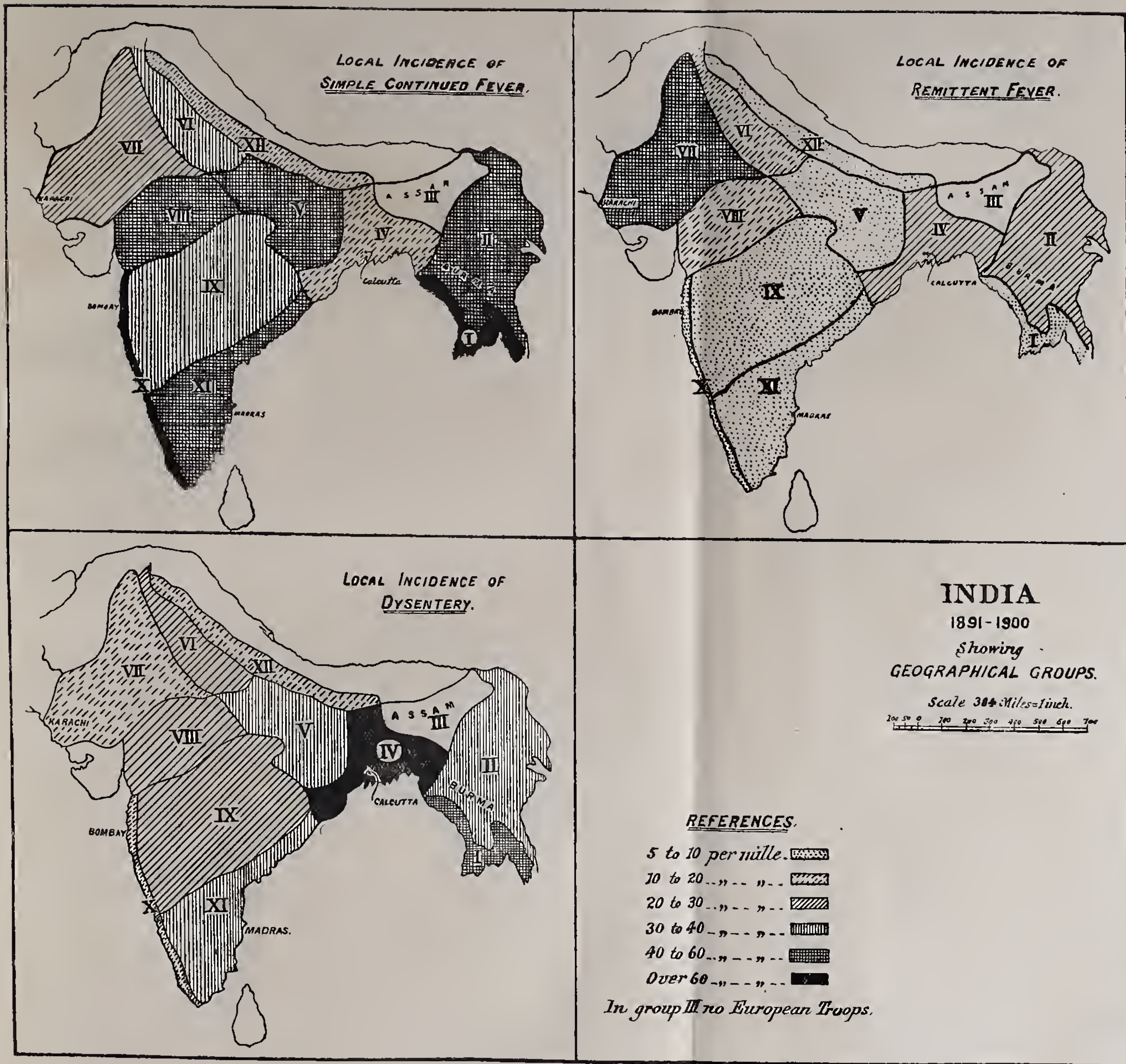
This aspect of of the subject will be referred to in the summary of the epidemiological characteristics of the disease which will be given in Chap. VII., but before leaving the subject of local incidence it is desirable to submit the following statements which show the relative incidence on the various Geographical Groups, of Enteric Fever, Dysentery, Simple Continued and Remittent Fevers, respectively, based upon the mean admission and death-rates for the decade, 1891–1900, with the case-mortality (*per cent*) in each case—(see Maps.)

Enteric Fever. 1891–1900.

Av. Strengths.	Geographical Groups.	Ratios per mille. A.	Ratios per mille. D.	Case Mortality per cent.
8,389 ...	1. Hills (XIIa.)	33·8	6·85	20·3
6,330 ...	2. S.-E. Rajputana and Central India (VIII.)	32·2	9·43	29·3
6,993 ...	3. Gangetic Plain (V. ...	30·2	7·46	24·7
13,325 ...	4. Upper Sub-Himalayas (VI.) ...	27·0	7·58	28·1
9,524 ...	5. Deccan (IX.)	21·5	5·30	24·7
4,741 ...	6. N.-W. Frontier, Indus Valley (VII.)	19·5	7·61	39·0
3,371 ...	7. Southern India (XI.) ...	16·9	3·71	22·0
3,376 ...	8. Hill Convalescent Depôts (XIIb.)	15·8	5·10	32·3
2,263 ...	9. Bengal—Orissa (IV.) ...	11·1	3·54	31·9
1,269 ...	10. Burma Coast (I.)	8·4	2·68	31·9
1,513 ...	11, Western Coast (X.) ..	7·3	3·17	43·4
2,572 ...	12. Burma Inland (II.) ..	4·7	1·83	38·9
68,224 ..	All India ..	24·2	6·46	26·7

Dysentery. 1891–1900.

	Geographical Groups.	A.	D.	Case Mortality per cent.
	1. Bengal-Orissa (IV.)	63·0	2·70	4·3
	2. Burma Coast (I.)	56·0	1·89	3·4
	3. Southern India (XI.)	33·0	·39	1·2
	4. Burma Inland (II.)	31·9	·54	1·7
Endemic Area. Enteric Fever.	5. Gangetic Plain (V.)	31·3	·83	2·7
	6. Deccan (IX.)	30·4	·72	2·4
	7. Hill Convalescent Depôts (XIIb.) ...	23·8	·74	3·1
	8. Upper Sub-Himalaya (VI.)	22·9	·69	3·0
	9. S.-E. Rajputana and Central India (VIII.)	22·4	·55	2·5
	10. N.-W. Frontier and Indus Valley (VII.) ...	19·7	·55	2·8
	11. Hills (XIIa.)	18·3	·37	2·0
	12. Western Coast (X.)	16·7	·60	3·6
	All India ...	29·6	·87	2·9


LOCAL INCIDENCE OF
SIMPLE CONTINUED FEVER.
VII
VI
XII
KARACHI
VIII
V
ASSAM
III
IV
II
IX
BURMA
CALCUTTA
BOMBAY
I
X
XI
MADRAS
LOCAL INCIDENCE OF
REMITTENT FEVER.
VII
VI
XII
KARACHI
VIII
V
ASSAM
III
IV
II
IX
BURMA
CALCUTTA
BOMBAY
I
X
XI
MADRAS
LOCAL INCIDENCE OF
DYSENTERY.
VII
VI
XII
KARACHI
VIII
V
ASSAM
III
IV
II
IX
BURMA
CALCUTTA
BOMBAY
I
X
XI
MADRAS.
INDIA
1891-1900
Showing
GEOGRAPHICAL GROUPS.
Scale 304 Miles=1inch.
100 50 0 100 200 300 400 500 600 700
REFERENCES.
5 to 10 per mille.
10 to 20 " "
20 to 30 " "
30 to 40 " "
40 to 60 " "
Over 60 " "
In group III no European Troops.

Simple Continued Fever, 1891-1900.

	Geographical Groups.	Ratios per mille. A.	Ratios per mille. D.	Case Mortality per cent.
	1. Burma Coast (I.)	86·5		
	2. Western Coast (X.)	74·0		
	3. Southern India (XI.)	54·6		
	4. Burma Inland (II.)	48·6		
Endemic Area. Enteric Fever.	5. Gangetic Plain (V.)	47·4		
Endemic Area. Enteric Fever.	6. S. E. Rajputana & C. I. (VIII.)	41·1	*	*
Endemic Area. Enteric Fever.	7. Upper Sub-Himalaya (VI.)	32·3		
Endemic Area. Enteric Fever.	8. Deccan (IX.)	31·8		
Endemic Area. Enteric Fever.	9. N. W. Frontier, Indus Valley (VII.) ...	29·4		
	10. Bengal—Orissa (IV.)	19·8		
	11. Hills (XIIa.)	19·7		
	All India ...	35·4		

* Note.—The death rate is inconsiderable, so low and inconstant in place and time, as to be negligible.

Remittent Fever, 1891-1900.

	Geographical Groups.	A.	D.	Case Mortality per cent.
*	1. N. W. Frontier, Indus Valley (VII.) ...	46·7	2·21	4·7
	2. Bengal—Orissa (IV.)	30·8	·53	1·7
	3. Burma Inland (II.)	21·7	·89	4·1
*	4. Upper Sub-Himalaya (VI.)	10·7	·47	4·4
*	5. S. E. Rajputana & C. India (VIII.)	10·3	·21	2·0
	6. Hill Convalescent Depôts (XIIb.)	9·7	·50	5·2
	7. Southern India (XI.)	9·1	·18	2·0
*	8. Gangetic Plain (V.)	9·1	·10	1·1
*	9. Hills (XIIa)	8·9	·19	2·1
*	10. Deccan (IX.)	8·0	·07	·9
	11. Western Coast (X.)	7·1	·13	1·8
	12. Burma Coast (I.)	5·4	·32	5·9
	All India ...	11·6	·44	3·0

* Note.—Endemic areas of Enteric Fever.

It will be seen that there are very marked contrasts in the local incidence of Enteric Fever as compared with that of the diseases returned under the other three heads ; there is a considerable similarity in the distribution of Dysentery and Simple Continued Fever, both being most prevalent on the wetter and coast areas and thus presenting the greatest and most definite contrast with Enteric Fever. The case of Remittent Fever is quite peculiar ; it is most prevalent in the driest and most continental area, least so on the Bombay and Burma coasts where the rainfall and humidity are at the maximum, but the comparatively moist areas of Bengal, Orissa and Burma also take high places in the returns ; and lastly, there is little difference to be observed in the incidence of morbidity on remaining six groups which are very diverse in their physical characters. This distribution is anything but suggestive of a single pathological entity especially when the relative case-mortality is taken into account. If further, the case-mortalities recorded for the different diseases be compared in the various groups we get no very definite and consistent indication of a direct or inverse relationship ; thus in the order of fatality they run as follows :—

Case-mortality by Groups.

Enteric Fever.	Groups.	X.,	VII.,	II.,	XIIb.,	IV.,	I.,	VIII.,	VI.,	V.,	IX.,	XI.,	XIIa.
Remittent Fever.	,,	I.,	XIIb.,	VII.,	VI.,	II.,	XIIa.,	XI.,	VIII.,	X.,	IV.,	V.,	IX.
Dysentery	,,	IV.,	X.,	I.,	XIIb.,	VI.,	VII.,	V.,	VIII.,	IX.,	XIIa.,	II.,	XI.

Too much weight must not, however, be given to the results herein disclosed for obvious reasons ; whatever may be said of Enteric Fever, it is certain that the cases recorded under "Remittent" represent more than one pathological process and this is, to some extent, applicable to dysentery. The conditions which determine prevalence in the case of any one disease do not operate equally everywhere on its fatality, and *a fortiori*, the force of the factors will vary still more when two or more diseases are concerned. The relations subsisting between Dysentery and Enteric Fever will, however, be fully discussed later (see Chap. VIII).

Having now demonstrated the endemic prevalence of Enteric Fever in certain defined areas, it is necessary to endeavour to trace and appraise the factors which determine this. These may be dealt with best under the three chief etiological heads, *viz.*, those in which the human host, the disease agent and the environment are concerned, respectively.

When we come to deal with corps units it will be seen how few escape infection during the first year of Indian service, and thus, first, the widespread and multiple sources of infection must be borne in mind. Next, and in connection with this factor, comes the influence of aggregation and especially on young, susceptible and newly-arrived subjects. Comparing periods of high and relatively low prevalence, *e.g.*, the mean rates for Enteric fever in the years 1897-1898 and 1900-1901, it will be found that in the former period the incidence of the disease on all stations having an average strength of less than 600 men (aggregate strength 30,184) is represented by ratios of 28·3 and 7·2 *per mille*, while for the larger stations, those with 600 men and upwards (aggregate strength 81,804) the corresponding ratios were 38·0 and 10·7 *per mille*. In the latter period of low prevalence, the contrast is still more remarkable; the smaller stations (under 600, aggregate strength 31,359) yielded rates of 9·3 and 3·2 *per mille*, while those occupied by over 600 men (aggregating 78,376), were affected to the extent of 17·9 and 4·6 *per mille*. We recognize then a direct relation between the extent of aggregation and the incidence of the disease, though this relation is not always exactly proportionate owing to the modifying influence of other factors, thus:

TABLE XXIII.

Influence of Aggregation on the Incidence of Enteric Fever.

Stations with average strength of	1897-1898. Ratios *per mille*. Ad.	1897-1898. Ratios *per mille*. Deaths.	1900-1901. Ratios *per mille*. Ad.	1900-1901. Ratios *per mille*. Deaths.
Less than 200	17·4	4·3	7·1	3·2
200 to 400	28·1	7·8	9·9	3·4
400 to 600	34·4	8·0	10·06	3·02
600 to 800	31·3	8·1	16·3	4·2
800 to 1000	28·9	8·0	15·5	3·04
1000 & upwards	41·9	12·2	19·3	5·4

It may be noted that the fall in the sickness rates in the period of decline (1900-1901) is much greater in the smaller stations; in those with average strengths of less than 600 it amounts to 67 *per cent*, while in the larger stations it is only

53 *per cent.* This is to be borne in mind in reading the remarks which follow on the *modus operandi* of aggregation and on the sources of infection.

The facts here disclosed are of extreme importance as bearing on the sources of infection, for if the specific virus were everywhere present in equal degree, as for instance among the natives and in their surroundings, we should expect to see the *rates* (*i.e.* the proportional incidence on strength) fairly equal everywhere, provided the *proportion* of susceptible subjects is equally distributed, which, indeed may easily be shown to be the case. On the other hand, we must recognize in this phenomenon the effects of the aggregation of larger numbers of young and susceptible men, involving multiplication of foci of infection and its dissemination by contact, mediate or immediate, among others more or less susceptible, and thus the maintenance of the chain of infection upon the human stage, *i.e.*, in the bodies of the hosts. As in the case of small-pox in an inadequately vaccinated community, the susceptible subject in the presence of infection, is not only in imminent risk himself, but is also a danger to others who are equally or less susceptible. Elsewhere, in the smaller self-contained communities, even with a proportionately equal number of susceptible subjects, the risks of infection are ordinarily smaller and less frequent, and these risks depend largely on importation by an infected subject; we may then have one or, at most, a few isolated cases; the physical and climatic conditions being unfavourable to the virus or comparatively favourable to the resistance of other hosts, more or less susceptible. Where all individuals are equally susceptible and equally exposed to an infection we do not see this contrast in geographical and strength-aggregation distribution, *e.g.*, compare Venereal disease (see later). These considerations go far to show that the British soldier is himself the chief source of the infection, and that this is maintained and spread by him under the conditions set forth.

But that aggregation, *per se*, does not determine prevalence is plain from the experience of the seaport garrisons already noted; out of the six, five have an average strength of upwards of 1,000 men, and the combined morbidity and mortality rates returned from these places in 1897-98, the period of maximum prevalence, were only 7·5 and 2·17 *per mille*, or less than one-fifth of the incidence occurring on stations in the same strength category elsewhere; this, also, in spite of the fact that the proportion of young and newly-arrived men exposed did not differ from that prevailing elsewhere. This contrast we refer chiefly to the influence of the environment on both host and disease agent as set forth previously. It is desirable to add that a detailed examination of the conditions, sanitary and other, under which the troops live in the seaport cantonments does not furnish any more definite clue to their relative immunity. It is true that three of the six are supplied with water from the Municipal systems, and in two of these cases it is laid on by pipes to cook-houses and barracks, but in the third it is distributed in iron buckets; Aden is supplied with condensed water which is distributed from reservoirs in iron buckets; Madras draws upon wells, and distribution is by buckets; and Rangoon depends upon similar sources and methods of distribution. It will be allowed that in these conditions there is little, if any, guarantee of exceptional safety; moreover while the sources and methods vary, all these places are alike in the contrast they present to the endemic area as regards the consistently small experience of Enteric Fever which they enjoy and have always enjoyed. And when again we look to the methods of conservancy in vogue, there is nothing to account for this; without going into details it may be said that, in practically all respects, the procedure is the same as that which prevails in all cantonments throughout the country, *viz.*, the "dry earth" latrine, with removal of excreta in filth carts to a trenching ground, or to deposit in deeper pits. Bombay alone pursues a system of its own, to the extent of using a solution of carbolic acid in place of dry earth in the latrines, and in removing the excreta in carts for final discharge into the sea.

In the next place, regard must be paid to the influence of traffic and inter-communication; the endemic stations are mostly situated on the main lines of traffic, and bodies of men, in the form of reliefs and drafts, are constantly passing to and fro between them. This greatly enhances the dangers of importation of the infection, the importance of which will be rendered clear in the next chapter, in dealing with the experience of Camps, of Campaigns and of the Hill-stations. The very notable bound exhibited by the rates in the Punjab and Bengal Commands in 1897-98, is doubtless to be attributed in large part to importation by infected men on return from field service. On the other hand, previous experience of the disease elsewhere also influences the local incidence, as may be seen in the fall in the rates, most marked in the same Commands, in the period during, and subsequent to, the Boer war, when the majority of the corps arriving in India had served a term in South Africa. There had been a temporary suspension of the supply of young drafts from the United Kingdom and thus, in spite of certain importation of the infection by these corps from abroad (see Chapter V.), we see greatly diminished prevalence of the disease in the places in which they were mostly located.

This leads to a final consideration to be adduced in this connexion, *viz.*, the effect of age and Indian service on local incidence, for this is also involved in the last-mentioned factor. First, it is necessary to show that there is no marked contrast in the proportion of young and newly-arrived men in the different Commands as a whole. In 1897-98 (the period of maximum prevalence) the distribution by age and length of service was as follows :—

TABLE XXIV.

Age Distribution by Commands.

	Percentages of Total Strengths.					
	Under 20 years.	20—25.	25—30.	30—35.	35—40.	40+
Bengal	3	52	36	7	2	1
Punjab	3	52	35	9	2	...
Madras	4	53	34	6	2	1
Bombay	4	51	36	6	2	1

Service in India.

	Percentages of Total Strengths.					
	Under 2 years.	2—3.	3—4.	4—5.	5—10.	10+
Bengal	39	17	15	12	14	3
Punjab	34	18	17	13	16	3
Madras	36	18	14	13	15	3
Bombay	34	19	16	12	15	3

So far, on this account we should not expect any special liability to the disease to be associated with any one Command more than with another, and it may be added that the age and service distribution in the seaport garrisons (the types of the true non-endemic area) conforms almost exactly to the above. But the case bears a very different aspect when we take the actual numbers of the fresh drafts (both as bodies of men and as individuals) and compare the Enteric incidence on the stations having the largest numbers of these with that on the rest of the area in which these stations are included; the result is to demonstrate that the incidence of the disease is always greatest where the actual numbers of drafts is greatest, save only in some of the non-endemic stations, *e.g.*, Bombay. We may take two stations in each Command having the largest numbers of drafts in the 5-year period, 1895-1899, and compare the results with those of the Command as a whole.

TALBE XXV.

Effect of Drafts on Enteric Fever incidence, 1895-1899.

	Total No. of drafts.		Combined Rates* Enteric Fever, 1895-1899.
	Bodies.	Individuals.	
Bengal Command as a whole	183	14,095	29·8
Lucknow	23	1,858	46·3
Meerut	27	1,511	38·2
†Punjab Command as a whole	155	12,952	34·5
Umballa	24	2,087	39·9
Rawal Pindi	40	2,971	30·4
Madras Command as a whole	108	9,108	7·9
Secunderabad	28	2,168	26·6
Bangalore	17	851	26·8
Bombay Command as a whole	132	9,482	21·5
Bombay	17	1,533	5·0
Quetta	19	1,686	41·5

* NOTE.—The combined Command rates are exclusive of the two stations taken as examples.

† Excluding the Hill-stations to which drafts were not sent direct (see later, Chapter V.).

These drafts are almost entirely composed of young men direct from the United Kingdom and having no previous service abroad; it must also be noted that the risk of the importation of the infection is involved in this consideration.

The figures serve to give an idea of the large number of separate bodies of newcomers, and of individuals, who join their corps units in a comparatively short period, and so of the importance of the traffic and importation factors.

Lastly, we shall take at random six of the larger stations in the Plains in the Northern (endemic) area and eight of the principal Hill cantonments, and compare the incidence of the disease in each series for two periods, *viz.*, 1897-1898, when the proportion of young and newly-arrived men was at its highest, and 1900-1-02, when this proportion was at a low ebb, on account of the suspension of reliefs during the Boer war.

TABLE XXVI.

	1897-98.				1900-1-02.			
	Proportion to total strength, per cent.		Enteric fever. R. *per mille.*		Proportion to total strength, per cent.		Enteric fever. R. *per mille.*	
	Under 25 years of age.	Under 2 years' Indian service.	Ad.	Deaths.	Under 25 years of age.	Under 2 years Indian service.	Ad.	Deaths.
Eight Hill-stations	58·2	51·4	52·4	8·4	48·8	22·9	14·1	2·9
Six Plains Stations	51·4	39·5	55·3	17·05	44·3	20·9	19·7	5·57

This table clearly shows the effect of the reduction of the numbers exposed to first experience of the environment, the fall in the proportion of men under two years' Indian service being far greater than that in the age-category; we may further recognize the effects of previous experience of the disease in the fact that many of the men (under 25 years of age) included in the second period had been exposed to infection in the first period. It will have been noticed that in the table exhibiting the incidence on the various geographical groups (No. XXI.) the morbidity rate of the Hill-stations (XIIa.) stands highest on the list, and a glance at the Station table in the Appendix will discover the majority of the Northern Hill cantonments to be among those from which the highest rates are returned. We shall defer the discussion of this important phenomenon till we come to deal with the experience of Camps, but it may be said here that these results are not due to the reception of drafts and reliefs, as these are not sent direct to Hill-stations. It is true that many young men arriving in India in the course of the winter trooping season are sent to the

Hills at the beginning of the ensuing hot weather, which, as will be seen is emphatically the Enteric Fever season in the Northern area, but it is important to bear in mind that they join their corps units in the Plains cantonments for a longer or shorter period of association, in the first instance. Nor again, is the remarkably prominent place these stations occupy as centres of the disease to be attributed altogether to the age and Indian service constitution of the forces located therein. It is true that the proportions of young and newly-arrived men are somewhat higher in the Hills than in the corresponding Plains stations from which the men are drawn, but the difference is inadequate to account for the results. In the last year (1903) for which alone data are available, the proportion *per cent* of men under 25 years of age and under two years' service in Plains stations was 50 and 41 respectively, the corresponding percentages for the Hills being 55 and 57 ; the latter figure certainly shows a considerable contrast, 57 against 41, as regards newcomers, but these facts refer to a season following the greatest influx of reliefs that has occurred since the Mutiny. After a suspension of the supply of men for two years during the Boer war, 18,600 men were drafted into India in the winter of 1901-02, and this influx was followed in 1902-03 by one of no less than 24,840 men ; this would affect the proportion of newcomers in the Hills to a greater extent than in the Plains. We cannot, therefore, ascribe the notable prevalence of Enteric Fever in the former places to the character of the *personnel* exposed ; at the same time we recognize that it is, indeed, highly susceptible and that owing to the fact that the men are cantoned in the Plains stations up to the time when the disease attains marked prevalence therein (end of March and beginning of April), there is every factor present for its introduction and dissemination on their arrival in the Hills. The view is widely held that the disease is, indeed, imported into the Hills, but that the original sources of infection are outside cantonment limits ; it is suggested, it is often asserted, that the men leave the Plains when Enteric Fever is rife and infection widespread in cantonments, free of the disease, and that they acquire it *en route* in Camps and other places, where the infection is derived from native sources. We shall not here deny this possibility nor prejudge the crucial question involved in this hypothesis ; but we hold it to be no more than a hypothesis, and later on facts will be adduced to demonstrate that it does not hold the field to the exclusion of a more rational interpretation.

Mention has been made of certain cantonments which now stand high in the endemic list, which were formerly occupied by new regiments for years without being attacked by the disease, not only as shown by its absence from the returns but also by the comparative absence of deaths from "fevers" in any form (Chapter II.). In this connexion, it is notable that it is on record that the Hill-stations of Northern India which, in recent years, have occupied the highest place for Enteric Fever among the geographical groups, had lower death-rates from "Fevers" (Enteric had not received a separate place in the returns) than any other group of stations in Bengal and the Punjab in the decade 1860-9, and as regards Dysentery, the death-rates were lower than in any other group save one, the Diarrhœa rate being only slightly higher than for the rest of the Northern Indian area (1·03 against 0·75), thus :—

TABLE XXVII.

1860-69.	Death Rates per 1,000 of Strength.		
	" Fevers."	Dysentery.	Diarrhœa.
Bengal Presidency (including Punjab) ...	3·58	2·72	0·75
Hill-stations	2·27	2·63	1·03

If we assume that all these deaths as recorded were due in part, more or less, to Enteric Fever, we get a combined death-rate of 7·05 in the Presidency as a whole, against one of 5·93 in the Hills ; but in 1894-98, the mean death-rate from Enteric Fever alone in the Northern Hill-stations was 8·12, from Dysentery 0·44 and from Diarrhœa, *nil*, which gives a combined rate of 8·56 *per mille :* and it is quite certain that here as elsewhere, there has been a very marked decline in the prevalence and fatality of Dysentery and Diarrhœa. This then must indicate a real increase in the prevalence of Enteric Fever in recent years and, further, the evidence in favour of the association of this increased prevalence in the Hills with that we have seen to have occurred in the corresponding Plains stations, is important and suggestive.

The other considerations affecting local endemic prevalence are those associated with the disease agent (virus) and with the environment. As to the former (the virus) we have the more abundant sources of infection in the endemic area owing to the greater and constant prevalence of the disease, the larger *actual numbers* of infected and susceptible subjects (drafts, etc.) which are being constantly renewed, and the greater risks of importation (traffic). And thus we must assume constant re-infection and greater facilities for the maintenance of the race (germ) in view of the constant occupation of infected sites under conditions of inadequate and ill-directed conservancy. As regards the environment, we have to regard it as operating on both human host and germ virus, and this will be studied best in relation to the seasonal incidence of the disease.

But first it is perhaps desirable at this point, at the risk of digression, to allude to one prominent factor in the environment as to which strong views are held and much controversy has arisen. Those who adhere to the theory of "water-borne" infection will look for a definite examination of its claims, and will doubtless consider that, after all, the essential factor in determining both local and seasonal incidence is the water-supply and the differences that characterize it in time and place. The present writer has no *parti pris* against the theory of water-borne infection, save as an exclusive doctrine which is persistently blind to some, to most, of the epidemiological facts which it is the purpose of this essay to establish, so far as the experience of the army in India is concerned. No one can possibly doubt the reality and the frequent occurrence of water-borne infection, but it fails to afford the clue we seek, for when positively established in any one case or outbreak, it merely indicates a link in the chain of causation,—a very important link in itself,—but it tells us little, too often nothing, of the prime source of infection. A study of the water-supplies of different areas and of individual stations does, indeed, as we shall see, assist us to a clue to certain definite phenomena of incidence, and all practical considerations demand such a study, if we are to avoid the pitfall of exclusive theory. But when we come to the details we find no ground for the easy assumption that the explanation of the main problem lies open before us. In the first place, there are no broad definite contrasts in the nature, conservancy and methods of the water-supply that would explain the contrasts of the local incidence of the disease ; generally, it may be said that Hill-stations are supplied by out-cropping mountain springs, while in the Plains the great majority of cantonments are served by wells of different (but no great) depths, the supplies being drawn from rivers or surface-streams and open reservoirs in the small remainder. The arrangements for raising, distribution and storage vary, but as regards all sources there has been a great extension of the provision of pipes for distribution during the last 10 or 15 years, and extraordinary efforts have been made everywhere since 1896, to purify the water by boiling and the addition of permanganate of potash. (See Appendix II.). These methods, however justified and well-intentioned, introduce very obvious dangers in the multiple processes and the manipulation involved, especially when the last link in the chain of protection, the method of storage, is defective, as is too often the case. When it is open to the men to dip their drinking-vessels into open-mouthed earthen receptacles in the cook-houses and in the verandahs of the barracks, it is of little avail to boil the water. Moreover, water that has been boiled and "pinked" with permanganate is not a delectable beverage in the hot-weather in the Indian Plains, if indeed, at any time or in any place, and there can be little doubt that the men are often driven by natural impulse to resort to unauthorized sources of supply. It should also be mentioned that large quantities of "mineral waters" of various kinds are consumed in every cantonment; in some stations these mineral waters are made from approved sources under the supervision of the regimental authorities, but a great deal is obtained in the native bazaar shops and refreshment rooms, and if simple filth be the effective cause of Enteric Fever it should doubtless be acquired in this way, and this to an extent that would not admit of question. But these risks and defects are common to the whole army wherever located in practically equal degree, and if the virus be omnipresent in the native surroundings, it is impossible to account for the phenomena of local incidence, than which no feature of the epidemiology is more marked or better established.

If, now, the facts be examined as to the incidence of the disease on the communities served by the different sources enumerated, we get no indication of a differential influence which can be associated with one or other of these sources; the disease is often more prevalent where mountain springs are drawn upon than in places supplied by filtered river water or by wells. It is precisely where the question of water-supply has received most assiduous attention, where some "system" in the shape of a filtered and piped supply has been instituted, that Enteric Fever is found to be most constant and most prevalent and this for one simple reason, *viz.*, that these systems obtain mostly in the larger stations in the endemic area, where the prevalence of the disease has stimulated these special efforts, but, as has been shown, other factors are in operation. If, again, we examine the records for the results of the installation of these systems, by comparing the rates for Enteric Fever during a period before and after their introduction, we are equally at a loss for any indication of their efficacy or influence in one way or the other; in a word, the disease prevails without demonstrable relation to any of these changes or improvements. It is certainly not asserted that improved conservancy of the water-supplies is a useless and negligible measure; such an assertion is open to the rejoinder that, in default of the measures taken, the disease would have prevailed even more abundantly, but it is difficult to substantiate the good results, on the facts available. For instance, combining the results recorded in seven large cantonments supplied by Municipal systems (filtered and piped) and comparing the mean rates *per mille* for a period of 5 years before and after their installation, we find them as follows:—

TABLE XXVIII.

Enteric Fever and improved Water-supplies.

5 years before.				5 years after.			
Enteric Fever.		Dysentery and Diarrhœa.		Enteric Fever.		Dysentery and Diarrhœa.	
Ad.	Deaths.	Ad.	Deaths.	Ad.	Deaths.	Ad.	Deaths.
33·3	7·84	58·5	·84	37·8	10·02	49·6	·86

In the two large stations with a piped supply from rivers, the intake being at a considerable distance, the combined Enteric rates were 22·3 and 6·02 during the 5 years previous to, and 19·4 and 5·8 respectively, in the like period subsequent to the installation, the Dysentery and Diarrhœa rates falling much more markedly. But this apparently favourable result as regards Enteric Fever, which cannot be said to be remarkable, is due to the fact that in the case of one of the Stations (Quetta) the second period stops short of the years of greatest prevalence of the disease; and if the results for subsequent years be taken we find a very considerable rise in the rates. This, indeed, is a consideration that enters into all the comparisons that are made in this connexion; where a new system or installation has been introduced subsequent to the period of greatest prevalence of the disease, *i.e.*, at any time after 1898, we see a diminution in the rates, but this, of course, is equally true of other places where the water-supply has always remained the same and unaltered. For instance, to take examples from Hill-stations with piped supplies from springs ; Dagshai and Sabathu were provided with their improved arrangements in 1898 and 1899, just at the end of the period of greatest prevalence of Enteric Fever and we find that the rates fell to a very great and notable extent in the subsequent years. But if we take Chakrata, which has been quoted as affording very strong evidence of the connexion of Enteric Fever with an impure water-supply, it is found that the rates have actually risen subsequent to the provision of an improved installation, when a sufficiently long period (5 years) is taken for comparison ; and this is because both periods, *i.e.*, that before and that following the installation, ran their course before the year 1898. Wellington (Madras) affords another example of this, a notable increase in the rates following an improved system of water-supply, and for similar reasons. In Dalhousie there is, again, little difference in the rates before and after the introduction of the piped supply, because years of high prevalence of the disease occur in both quinquennia, 1892-96 and 1897-1901. Finally, it may be said that two cantonments with piped supplies from large surface reservoirs (Jubbulpore and Mhow) exhibit an enormous increase in the rates for Enteric Fever, and, to a less extent, for Dysentery and Diarrhœa, since the introduction of their systems. Now these works have all been undertaken after careful enquiry and have constantly received more assiduous attention than the sources that have remained practically the same throughout. The objection may be raised that in many instances there has been lack of judgment or mismanagement in details, or, indeed, in the new departure as a whole, but even if this be granted we are no nearer to an explanation of the epidemiological facts as a whole, and we are driven to the conclusion that other factors are in operation of a far more potent and immediate influence. Those factors we have endeavoured to indicate, and we do not deny a place among them to the nature and conservancy of the water-supplies as will appear in the sequel.

We have now to turn our attention to the phenomena of the seasonal incidence of the disease in different areas and to apply the same tests for their elucidation.

At the outset, it is to be remarked that the subject, when all the issues are taken into consideration, is one of such wide range that its adequate discussion would fill a treatise by itself; the great diversity of the physical and meteorological conditions which characterize the many different areas comprised within the Empire present formidable difficulties to summary treatment which will be at once clear and complete. We shall, therefore, be compelled to assume an acquaintance on the part of the reader with most of the essential facts in regard to the surface geology, the geography, the meteorology, and the hydrography of the country, to which the brief sketch given in the previous chapter will serve as a general guide, but which is necessarily inadequate in detail for the comprehension of some of the important natural processes which determine the local and seasonal incidence of disease. This is especially the case as regards what may be called the anatomy and physiology of the soil and the subsoil, its structure and its "respiratory" and "circulatory" functions under the influence of complex meteorological conditions: these phenomena have an essential connexion with the problem before us, but it will only be possible to refer to some of the more pertinent of their relations in passing.

In the first place we may recall, as briefly as possible, a few points which have an important bearing on the relation of the bacillus to the soil and to the ectanthropic environment generally, in connexion with its saprophytic life-stage and the means of its dissemination. The materials of the soil, natural and acquired, organic and inorganic, are perpetually undergoing decomposition in a rhythmical cycle and thus the necessary pabulum becomes soluble and accessible to the living organism. The soil must then be regarded as no mere inert stage upon which man alone struts his little part, but as a theatre for complicated and well-ordered physiological processes upon which life in its completest sense depends.

As regards the necessary pabulum we know that the schizomycetes require Nitrogen and that they obtain it from soluble albuminates, ammoniacal salts and nitrates; the latter have been shown by Klein and Emmerich to be specially favourable to the lifeprocesses of *b. typhosus*. It is unnecessary to enter into the details of the chemical and biological processes which are involved in the formation of these substances, to which may be added the compounds analogous to "amides" (asparagin, urea, etc.) which afford an excellent substratum for the growth of micro-organisms. We may merely note that nitrates in the soil are always combined with an alkali (K. Ca. Na. etc.), that they are never fixed, but freely soluble, and complete washing removes them. The soil is the repository of the excretory refuse products of man, and these are abundant in every cantonment and its surroundings. Nitrification and the other transformations alluded to are probably specially active in India in the spring or early summer, the period of fallow after the winter crops are harvested, when the leaves fall, and there is abundant refuse vegetation for decay; the period also of rising temperature (soil and atmospheric), of light and occasional rainfall and of greatest aeration of the soil. Dr. Leather (Agricultural Chemist to Government) has been good enough to inform the writer that from recent experiments at Cawnpore, he estimated that about 40 lb. of Nitrogen per acre were changed from the organic state to that of nitrates during the period October 1903 to June 1904, and that the corresponding quantity in 1902 to 1903 was about 60 lb. in the farm soil; he adds that "these figures are probably below the truth."

In the absence of O, as when the soil is sealed by rain, reduction processes occur: nitrates to nitrites, to ammonia and to N. Nitrates are shown to increase with increase of temperature (the optimum being at about 37°C., or blood-heat) and in the period of fallows; they are reduced by vegetative growth and cropping, and by the scouring and percolation effects of heavy rainfall, which also acts to seal the soil and deprive it of the necessary oxygen for the time.

We may now refer to one or two facts that are often overlooked. The first is that the soil is not devoid of moisture even at the height and end of the hot season. Apart from the many spots in the inhabited site constantly subjected to the deposit of liquid waste, Dr. Leather informs me that, in ordinary arable soil, he has found 5 *per cent* of water at a depth of 6 inches and 10 *per cent* at 10 inches, at the end of the hot weather after months of drought. Another fact is that urine readily forms ammoniacal salts in contact with a soil containing lime; again, clay when present (as in the alluvium of the Indo-Gangetic plain) either in consistent strata or in discrete admixture, has a strong affinity for ammonia and the organic acids of humus, as well as for all foul organic products. This is shown by the simple experiment of mixing clay with urine whereby putrefaction is deferred or avoided, and by the fact that clay is an excellent precipitant for sewage in suspension. We note, then, certain specific properties of lime and clay which are important constituents in the soil of our endemic area ; this fixing power, while it may protect the deeper layers of the soil and the ground-water from immediate and direct pollution, operates to provide a nidus and reservoir for large quantities of dissolved or suspended impurities in more or less proximity to the surface.

Along with this we have to take into account the following factors : the amount and character (intermittent or persistent) of the rainfall ; the effects of first rain after drought and of subsequent precipitation ; the nature and depth of the sub-soil ; the level and range of fluctuation of the ground-water ; and with these, the atmospheric and surface soil temperatures (solar heat), the atmospheric humidity and the prevalence and force of winds. These are the chief dynamic forces that operate upon the more or less static nidus to effect transportation of the disease agents contained therein.

We shall not attempt a discussion of these phenomena and of their interaction in the drama of the birth, life and death of all organic beings ; it must suffice to bring them before the minds's eye and to emphasize in the most general terms man's intimate relation with the environment. And for the rest, the more important indications will be illustrated as we proceed with the statement of the facts of the local and seasonal incidence of the disease, and judgment should be suspended until we come to summarize our conclusions at a later stage (see Chapter VII.). To those, however, who desire to obtain a clearer picture of the forces in operation and of the respiratory and circulatory processes of the soil as they affect the respirable atmosphere and the water-supplies, the study of the phenomena of the production of "Reh" over large areas of Northern India is commended. We get in this a demonstration, on a large and obvious scale, of processes which have the most direct bearing on the problem before us. "Reh" is the term which denotes the deposit on and in the soil of certain salts (chiefly sulphate and chloride and carbonate of Sodium) which are the products of rock and soil disintegration under the action of O and CO^2 in water. These deposits appear chiefly in two forms and at two distinct levels ;—as an efflorescence on the surface, and in solution in the ground-water with deposit just above this ; the time of their production, their amount and their depth from the surface, in the subsoil, depend upon the season of the year, the chemical composition and permeability of the soil, the character of the rainfall and the surface and subsoil drainage. Account must be taken of the action on the surface and in the strata permeated by the ground-water, and of the relations between the one and the other. Decomposition is most active on and in the surface under the influences of heat and moisture, but with good surface and subsoil drainage, along with cultivation, there is a constant utilization and escape of these salts and there may be difficulty in getting enough of them. At the ground-water level they are also generated, and here they are reinforced by those transported from the surface by rainfall. The first rain after drought carries them down beyond the range of the surface scour of succeeding rain, and if the soil be porous, the ground water at a fairly high level and the rainfall abundant and persistent, percolation gravitates to the permanent water-bed which then becomes a reservoir for surface salines. If less porous, and interspersed with sheets or discrete deposits of clay, the soakage may only proceed for a few feet in depth. Subsequently, between the falls of rain, where this is more or less intermittent or at the conclusion of persistent rain, the forces of evaporation come into play (solar heat, wind, &c.); a returning upward current is set up by capillary action, the water and CO^2 pass off into the atmosphere, the solution becomes more concentrated until deposit occurs in the form of efflorescence (compare the "damp-line" on house-walls and the efflorescence of nitrous salts.) Similar results are observed above the upper level of the ground-water, which also, by rising under the influence of rainfall and its other sources of supply, may bring its saline contents into close relation with the surface to appear subsequently as an efflorescence thereon under the influence of the forces alluded to. On the other hand, the ground-water, when rising and at its highest, is well diluted and able to dissolve large quantities of salts and it will depurate the soil through which it flows. As it frequently rises to within the zone affected by rain percolation, we need not always postulate a direct communication between the rainfall and the ground-water; the latter washes the strata to which salines and other materials have been carried down by percolation, but the rise of the ground water to its highest point is generally delayed till after the acme of rain precipitation; moreover, the great body of the ground-water is derived only indirectly from the rainfall.

Much has been made of the comparatively short range of percolation of rainfall in porous soils (save in the case of fissured rocks) as against the view of the direct pollution of well-waters in this way, but little regard has been paid to the influence of the rising tide of a highly fluctuating ground-water, reinforced from below and brought into contact with the organic reservoir of the soil.

The results will, of course, vary in the case of a pure sandy desert soil with a light rainfall and a low ground-water, and in that of an alluvial site subject to constant pollution, with more abundant and persistent precipitation, a high and fluctuating ground-water and faulty drainage.

Now obviously the same factors will effect equally in most respects, the production, distribution, and circulation of nitrogen salts and other pabulum, as well as of the micro-organisms whose life processes are thereby subserved. The influences will be recognized to operate variously at the periods of highest and lowest rainfall and ground-water, respectively, and at those of rising and falling ground-water, but if the conditions are borne in mind we may be able to reconcile the conflict of testimony by which the subject has been obscured. The main point is that vital processes in the soil may be brought into relation with man, on the one hand, through the atmosphere or by more or less direct relations with the surface soil, and on the other hand, through the medium of the water-supplies. The practical indications, further, are fully supported by the analogy of "Reh" ; the most effectual "cure" for this is subsoil drainage which permanently lowers the ground-water, and for our purposes, where this procedure is impracticable we should draw our water-supplies from below the first water stratum by means of deep or artesian borings. Again, very heavy and persistent rain will relieve a soil of "Reh" for the time, and similarly will suppress an outbreak of disease forthwith (as in the case of Cholera in Bengal), or, subsequently, as in the cases of Diphtheria and Enteric Fever (see Chapter VII.). Vegetation and cultivation also act powerfully to reclaim a "Reh" soil by promoting assimilation of the salts and by shading the ground and thus diminishing evaporation. This also is the classic method of rendering a soil "healthy ;" if we look no further than to the effects of dust and damp, we may recognize its *rationale*.

Lastly, it should be noted that the "Reh" phenomenon occurs in a distinct area well marked by its meteorological and other physical characters, *viz.*, over a large part of the Punjab, the United Provinces and Rajputana, thus coinciding closely with our endemic area for Enteric Fever : here we have a porous alluvial soil, moderate to small rainfall, frequently high ground-water and excessive heat ; this also is the area of dust storms. Elsewhere, notably in the coast areas and lower in the Gangetic Plain (Bengal proper), where the rainfall is copious, the salts are diffused through the soil and the air stratum covering the surface contains much more moisture, which greatly diminishes the effect of solar heat (invisible vapour absorbs heat), and there is also much more cloud to act in the same way.

The special physical features of that part of the endemic area which lies south of the Vindhyan hills will be discussed later, but it may be said at this point that in a notable respect it must be classed with the former, *i.e.*, the dry continental area, in that both provide the great wheat field of the empire ; the cultivation of wheat on a large scale may be said to be practically restricted within these limits. The large demands made by this crop for nitrates is well recognized, and we shall see later (Chapter VII) that the amount and distribution of the rainfall have very similar effects on the yield of wheat and on the prevalence of Enteric Fever in the succeeding year.

It is, moreover, necessary to keep the other etiological factors steadily in view if the facts to be adduced are to render their full significance. We refer, of course, to the human host, to the parasite and to the intermediary agents of infection, each of which will be discussed in due course in its connexion with the seasonal incidence, but a few general remarks are called for in the first place, as certain important considerations are commonly overlooked or underestimated. On the view previously set forth it would seem clear that the sum of the phenomena that constitute a definite climatic process, *i.e.*, a season marked by heat or cold, should operate to affect the mutual relations of host and parasite. For by the terms of the equation infectious disease could only arise and become a constant epidemiological phenomenon under circumstances which favour the propagation and virulence of the germ while lowering the resistance of the host. A contest is set up between the former and the tissues of the latter, the particular tissue attacked being different in the case of each "zymotic" disease, which could only arise in circumstances which favour the life activities of the one, while depressing those of the other at the same time. This affords a clue to the seasonal periodicity of germ diseases, as well, as will be seen later, to the phenomena of individual and racial resistance (Chap. VIII.). We see Pneumonia most prevalent in the cold and transition periods of the year and at high altitudes, when and where the physiological stress is on the lungs; bowel complaints prevail in hot weather and in low latitudes, when and where the stress is on the abdominal viscera. In each case there are important changes in the blood and other tissues which largely depend on and are promoted by changes in the habits of life, which the different seasons involve: aggregation in dwellings, factories, dietetic changes, nature and amount of work and fatigue, &c. The resistance of the different tissues will therefore vary at different seasons,* and on the other hand the primitive forms of floral life (micro-organisms) must follow the laws of their kind and be still more subject to seasonal influences; it is, further, established that toxic agents, both organic and inorganic, have elective affinities with special tissues. We have, then, to recognize seasonal variations in the degree of adaptation, in the ratio of fitness to withstand the strain imposed on different organs and tissues under different conditions of temperature, &c., which is an epitome of the whole process of adaptation to which the life of the individual is subject. If this be the case under the conditions of the natural habitat, it is clear that the processes will be greatly exaggerated by a sudden transfer of the host to an alien environment where the climatic forces are far more powerful and the extremes far greater, and thus we may recognize in the factor of "first exposure" the danger of maladaptation in its highest degree. Under the strain of excessive and disordered function, the parasite, if it gain access to the body, finds the tissue cells with which it has affinity unable to repel attack; it multiplies, producing poisons which impair resistance still further and a focus of inflammation is developed locally from which general systemic toxication proceeds. Our point is, briefly, that both host and parasite are definitely subject to the influence of the environment as it operates in seasonal changes,

* Corresponding to the course of the physiological cycle, as determined by the course of the seasons, habits of life, &c. In primitive times (and even up to within the last two centuries in the West) the daily food of man varied markedly with the seasons, as is the case to-day among most primitive peoples living on the land. They exist literally from hand to mouth on the bounty of the soil, without the provision for an equal distribution of food products throughout the year which the modern economic era has rendered possible for centres of high civilization by the tribute of all parts of the world. Having regard to the rôle of the tissue cell in the processes of immunity (Ehrlich), it can scarcely be doubted that the production of "anti-bodies" depends largely on the nature and amount of the food and on the whole physiological cycle under the influence of definite seasonal changes.

that both live and thrive by adaptation only and that the problem of colonization or acclimatization is the same for both, a contest for supremacy by an immigrant race. The victory will rest largely with one or other belligerent according to the conditions of life to which each is subject at the time at which the physical influences of climate and season are the most important factors of the environment.

The influence of the host on seasonal incidence is clear when we regard it as providing the "soil" and the climate for the parasite. Conditional pathogenic germs, as purely saprophytic plant organisms, are entirely subject to local and seasonal influences for their growth and propagation, but when parasitic, their life conditions are modified and their existence will not be so strictly conditioned by definite seasonal influences, because as parasites they enjoy an equable and optimum temperature (climate) with abundant pabulum. Their existence will then depend on the extent of the susceptible *personnel* available and on the means of access thereto ; their original seasonal limitation as saprophytes will therefore be modified in direct proportion to the degree of parasitic faculty they evolve by adaptation ("acclimatization"). The seasonal distribution of malarial fevers is determined by the life conditions of the host (mosquito) ; and subject to this main condition we see climate and temperature operating through the host, on the one hand, to favour the development of the parasite in the mosquito, and on the other hand, to lower the resistance of the human host, as seen in the effects of a storm in the Bay or in the English Channel on previously infected subjects homeward bound. The best chance of seeing cases of malaria in the London or Liverpool hospitals is to time one's visits by the indications of the weather reports. Another aspect of the influence of the human host is exhibited in the contrast in the seasonal incidence of the mortality on different races under similar conditions. Compare the mortality as recorded from the European and native troops of the army in India as regards its relation to heat and cold, in the two bodies respectively :—(see Table XXIX. next page.)

This striking contrast must be attributed in largest measure to contrasts in resistance evolved in the different races by previous experience of the chief causes of mortality ; it is an expression of the effect of seasonal influences on the main forces of evolution, and while these may operate similarly on different races, they do so in very different degrees at the different stages of that evolution. Thus the seasonal distribution of mortality may also

TABLE XXIX.

	Percentage of total mortality.	
	Hot Season (May to October).	Cold Season (November to April).
	Per cent.	*Per cent.*
European troops ...	62	38
Native troops	37	63

indicate the conditions under which a given disease first originated in a former stage of civilization, and when different regions of the world are compared we may account for the varying relative prevalence of different diseases. In this connexion, some striking results are demonstrated when we take what may be called a bird's-eye view of any one region, the physical conformation of which permits us to apply the test of altitude in place of that of latitude or distance from the equator, with the definite gradations of climate thus provided, and to which bodies of men of the same race are exposed simultaneously. The following statement is extracted from the report of the Sanitary Commissioner (India) for 1897 and gives the admission-rates *per mille* for the three years, 1895-97, for the chief diseases as recorded in groups of stations at different heights above sea-level. Convalescent depôts and those stations of which the heights are unknown have been excluded. The figures present the results of a comparatively short period, and they refer to European soldiers only; the average strength exposed varies greatly in the different categories, and hence too much weight must not be given to the significance of certain blanks in some of the columns; the effects of importation and of varying degrees of aggregation have also to be taken into account.

Malarial fevers, dysentery, cholera, hepatic affections, heat-stroke and "all causes" declined with height in a fairly consistent and direct ratio; tuberculosis, pneumonia and rheumatic fever, on the contrary, increased with the rise above sea-level. The former diseases are precisely those we have seen to be associated with life in the tropics and as bearing most severely on new arrivals therein, whereas the latter are pre-eminently associated with the higher latitudes (see also Table XII, Sickness and Mortality in Hill stations, Chapter II.). We have yet to deal with the phenomena of Enteric fever incidence in the hills, and for the

TABLE XXX.

Sickness in relation to altitude. European troops, 1895-97.

	Height above sea-level in feet.						
	a	*b*	*c*	*d*	*e*	*f*	*g*
	Below 100.	100 and below 500.	500 and below 1,500.	1,500 and below 3,500.	3,500 and below 5,000.	5,000 and below 8,000.	8,000 and below 13,000.
Influenza	18·3	12·2	6·6	4·7	·4	5·1	..
Cholera	·3	3·4	·7	1·0	...	...	...
Small-pox	·1	1·4	·9	1·1	...	·1	...
Enteric Fever	10·4	26·9	30·3	24·3	107·3	33·7	15·0
Intermittent Fever ...	388·9	234·7	389·8	268·7	189·7	188·0	165·4
Remittent Fever ...	19·0	18·8	15·0	10·1	38·5	7·1	7·5
Simple continued Fever ...	35·9	80·4	21·6	21·9	1·9	10·7	7·5
Rheumatic Fever ...	·6	·6	1·2	1·2	6·6	3·4	...
Heat-stroke	3·1	6·2	5·9	1·7	1·9	·2	...
Circulatory Diseases ...	9·6	9·2	9·1	5·4	20·2	12·0	15·0
Tubercle of the Lungs ...	3·3	3·6	3·1	5·1	5·8	3·9	...
Pneumonia	1·6	2·5	5·7	4·4	1·6	5·0	11·3
Other Respiratory Diseases	20·5	21·3	29·1	28·6	11·3	27·3	22·6
Dysentery	41·9	32·5	26·3	28·6	18·7	18·9	3·8
Diarrhœa	21·1	21·8	22·8	19·2	29·9	26·7	3·8
Hepatic Abscess ...	2·8	2·4	1·7	2·1	1·9	1·2	...
Hepatic congestion and inflammation ..	22·0	23·6	16·5	19·3	5·4	15·2	22·6
Venereal Diseases ...	471·6	572·1	538·5	522·7	302·8	528·0	330·8
ALL CAUSES... ...	1,510·2	1,518·2	1,542·9	1,354·9	1,108·8	1,332·8	1,022·6

other diseases we need not dwell on the significance of the salient facts and their practical application after what has been said ; the effects of temperature, direct and indirect, are, of all the factors in operation, the most clearly traceable. There is, however, one consideration which has not received the attention it deserves, and that is the contrast in the geographical pathology of similar latitudes north and south of the equator respectively ; compare the Southern States of N. America, the West Indies and

Algeria on one side, with South Africa and New South Wales, on the other side, at fairly equal distances from the tropic belt, in regard to the relative prevalence of tropical diseases (Malaria and bowel complaints). The European can, in fact, approach with comparative impunity much nearer to the equator from the south than from the north,* while, at the same time, he may become adapted to the simple and direct effects of heat, the advantages of which will be demonstrated on his subsequent transfer to a tropical region.

Finally, we shall see that with a reversal of the seasons according to latitude, north and south, the seasonal incidence of Enteric Fever and other zymotic diseases is similarly reversed; that where a definite seasonal influence occurs twice within the year there is a corresponding double rise in the curve of disease incidence and that, generally speaking, the seasonal incidence is more definitely marked in proportion to the extremity of the climatic contrasts (compare sea-coasts, plains and hills).

Enteric Fever has always and everywhere been associated with very definitely marked seasonal periodicity, but equally definite conclusions as to the precise *modus operandi* of the controlling factors have certainly not been attained. In Great Britain, as in Europe generally and in North America, where, of course, the subject has received the closest study, there is remarkable unanimity of testimony to the fact of its maximum prevalence in the late summer and autumn months, and beyond this, to its almost exclusive association with this period of the year when in anything like epidemic form, though instances are numerous in which severe epidemics have extended into the winter months, but thenceforth the disease gradually declines into a more or less sporadic form, to reach its minimum in spring and early summer. Thus we may say that, in the West, the period August to November provides the conditions for the maximum prevalence, while March, April and May yield, as a rule, the fewest cases. But while this is so, and very definitely so, we find abundant and suggestive instances of non-conformity to the general rule; as has been said, the records of the greater epidemics provide examples of this, and it may be affirmed that the tendency to seasonal aberrations has been greater in recent years as regards outbreaks in civilized urban communities, while we still find fairly strict conformity in rural areas. This change is doubtless due to altered conditions of civilization,—to the

* Compare the Transvaal Colony with Central India, both in approximately the same latitude, North and South.

provision of common water and sewerage systems and to aggregation in large urban centres, and here, chance specific pollution of the water-supply at any season will frequently involve the infection of large numbers of the population served thereby. A sporadic case of the disease, perhaps arriving from elsewhere, may provide this pollution (and sporadic cases are of constant occurrence in all large urban centres at all times), and such an outbreak will then develope independently of general climatological considerations. Again, such water-supply systems derived from river sources are subject to the influence of any sudden, and perhaps abnormal, access of storm-water,—heavy rains, or the melting of snow and ice at the source; the former will sweep impurities from the soil into the stream and the latter may set up a "spate" and overflow of the stream with similar consequences. The frequent extension of the prevalence of the disease into the winter months in London is reasonably associated with the Thames floods, which often occur in the Autumn; the gales and storms of the Spring equinox may occasionally determine an outbreak much earlier in the year. Where, on the other hand, in rural areas the water-supply is from separate wells, where an outbreak depends chiefly on some form of linked or mediate infection from case to case as by contaminated dust or insects, &c., and where the viability of the virus in external nature is, more or less, involved, there is far greater conformity to the general rule of autumn prevalence. There is here, indeed, an important indication of a very definite influence exerted by the environment on the micro-organic agent of the disease, on its power of multiplication and vital activity; and for the rest, we must look to these external influences as affecting both the human host and the means of conveyance of the infection from one host to another, directly or indirectly. For example, there is the holiday season, traffic to and from, and aggregation in, holiday resorts with all the physiological and hygienic disturbances involved; and, on the other hand, the multiplication of insect life, the prevalence of dust, the greater consumption of raw fruits and vegetables at this season, &c. A broad general law may, indeed, be formulated that a hot dry summer in Europe is generally followed by an excessive rise in the autumnal Enteric curve,—a sequence so frequently observed as to have given rise to the well-known Buhl-Pettenkofer theory of the dependence of the disease on conditions associated with a fall in the level of the ground-water. As leading up to the discussion of the facts as displayed in

India, we may first note one or two points regarding the seasonal incidence in Egypt and South Africa.

Sandwith has recently stated that Enteric Fever is most prevalent in the British garrison in Cairo in the last quarter of the year (October-December), and he gives the monthly incidence (*per cent.*) based on the experience of private practice, as follows :
January 15, February 19, March 17, April 5, May 4, June 1, July 1, August 1, September 6, October 11, November, 8, December 11, which shows a definite rise in September, culminating in January to March, and thenceforth declining through the summer months. It is true that the tourist season is in abeyance in the summer, but the incidence conforms generally to that on the troops present throughout the year, and the distinct rise in prevalence occurs before the tourist season begins. Now in Lower Egypt the regular rise of the Nile does not take place till some days after the summer solstice (*i.e.*, end of June), and the inundation occurs two months later. The river attains its greatest height about the end of September, and then, falling more slowly than it rises, sinks gradually to its lowest point in the following June ; it is said to rise about 25 feet at Cairo ("*Encyc. Britannica*"). We see then the greatest height of the Nile coinciding with the sudden rise in the Enteric curve (September) ; the rise in the river causes percolation through the soil, which abounds in filth and cesspits, and thus the ground-water is reinforced by the tide which must wash out impurities of the most dangerous nature, and so pollute the wells from which the drinking-supplies are drawn. On the other hand, with the subsidence of both river and ground-water to their lowest levels, the disease declines to its minimum point. The meteorological conditions of Egypt are so peculiar and well-defined, that these phenomena have an instructive bearing on the problem when presented under more complex circumstances. (See Chap. VII.)

Observations made in South Africa are equally suggestive from another point of view and serve to throw light on our own particular problem. Turner has published the data for the Transvaal, showing the monthly incidence of Enteric fever along with that of the rainfall in the form of a chart, the salient features of which will be clear from the following statement :—

	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.	Apl.	May	June.	July.	Aug.	Sep.
Rainfall (Ins.)	1·5	3·5	4·5	7·0	4·0	2·7	0·8	0·6	0·2	0·1	0·16	1·1
Enteric Fever (Notifications)	4	24	36	114	49	27	24	14	14	9	16	20

The rainfall is practically confined to the period November to March and is precipitated in a series of heavy thunderstorms at short intervals and thus has a very definite "Monsoon" likeness to Indian conditions; and we see the almost exact coincidence of the two curves, which both culminate in January, rising and declining *pari passu*. The period, January to March, in South Africa has remarkable analogies with that of August to October in India, both as regards physical conditions and the incidence of Enteric Fever.

Major Simpson, R.A.M.C. (*Army Med. Report*, 1898), gives the following data for Pietermaritzburg, Natal.

TABLE XXXI.

ENTERIC FEVER. AVERAGE CASES, 1888-1897.

Rainfall, Average inches, 1886-1897.

	July.	Aug.	Sep	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.	Apl.	May	June
Enteric	0·7	0·2	2·1	3·7	3·8	7·4	5 6	4·0	2·8	2·1	1·9	0·4
Rain ...	0·4	1·3	2 2	4·0	5·0	6·0	7·5	7·4	7 0	2·3	1·4	0·5

Seventy-three per cent. of total rain falls in the November—March period, which is also the hot season—the temperature, rainfall and Enteric curves corresponding very closely.

It is to be noted that while in Europe generally there is, as a rule, an inverse relation between the prevalence of the disease and the rainfall, or a direct relation to drought, which is recognized also in connexion with other disorders of the bowels (notably infantile diarrhœa), we have here an example of a direct relation to rainfall, which is most instructive for us, as will be seen shortly.

The records of the South African War while presenting certain features in conformity with the definite incidence just shown to prevail in the Transvaal, exhibit notable aberrations therefrom, which must be attributed to the special conditions under which the army was exposed: *e.g.*, the aggregation of large bodies of susceptible men in insanitary camps, rapid movements involving importation from camp to camp, and with this, the season of concentration and the numbers concentrated at different times and places. In the first year of the campaign from October 1899 to September 1900, the greatest prevalence of the disease was recorded in April, May and June when the maximum was reached, along with the steady increase of the strength exposed, a great decline in the number of cases occurring in September. During the second year, the rise was observed in November and December, the greatest prevalence occurring during the next four months to culminate in May and to fall in June to one-third of the extent of the May total. Here we may see the important influence of the factor of the human host in modifying seasonal incidence, evidence as to which will be furnished from Indian experience. Lastly, Welch has recorded the general conclusion that the disease among the troops in the tropical and subtropical colonial garrisons is found to prevail to the greatest extent during periods following rainfall, and that it has been almost invariably accompanied by preceding outbreaks of anomalous continued fevers and bowel complaints.

The way is now clear for a statement of the position we have to deal with in India, and it will be advisable to take first a brief general survey of the large inclusive areas, and then to pass on to the more definite geographical and climatological unities, the "groups" previously referred to, the evidence being supplemented by a study of the incidence in a series of typical cantonments in each main group. Nothing short of a detailed analysis will avail to indicate the operation of the various complex factors at work, but it is obvious that the mass of material derived from such extensive experience can only be subjected to summary treatment in the text, the charts being referred to for fuller details.

TABLE XXXII.

Seasonal Incidence of Enteric Fever.

Quarterly Percentages, 1870—1889 (20 years).

Presidency Armies.	Quarterly percentages.*				
	January to March.	April to June.	July to September.	October to December.	—
Bengal *	13	40	29	18	=100
Madras	15	19	49	17	=100
Bombay	16	20	41	23	=100
INDIA	14	34	34	18	=100

* Bengal Presidency includes Punjab.

Dealing first with the period of greatest prevalence, *i.e.*, up to the year 1898 and before the disturbing influence of the Boer war on the age and service constitution of the army came into play, we may note the broad contrasts in the seasonal incidence displayed in the different Presidencies, which were subsequently redistributed as "Commands" in the year 1895.

Taking Bengal as representing the Northern and continental area, while the other two Presidencies are included in the peninsula, we see how marked the contrast is, especially as regards the relative incidence on the second and third quarters; further it will be noted that the disease is abundantly present at all seasons of the year though in decidedly different degrees. Coming now to the later period of distribution by Commands we get the following results :—

TABLE XXXIII.

Seasonal Incidence of Enteric Fever by Commands, 1895-98.

COMMANDS. (PLAINS STATIONS.)		Quarterly percentages*.			
		January to March.	April to June.	July to September.	October to December.
Cantonments in the Plains only.	Bengal	23·5	34·0	19·8	22·7
	Punjab	10·2	42·9	24·9	22·0
	Madras	22·4	21·0	36·4	20·3
	Bombay	13·2	22·0	43·3	21·5
INDIA		18·1	31·3	28·1	22·4

* Quarterly percentages. It should be noted that this ordinary arrangement of the quarters (January to March, &c) fits in with the four seasonal periods of the year (mid December to mid March, &c.) when a fortnight is allowed for the average period of incubation (see Chap. III.)

This latter period is that of the highest recorded prevalence, and while the broad results are similar to those of the former, there is an increase in the proportions falling on the first and last quarters which, as will be seen later, is largely due to the effects of the Frontier campaigns in 1897-98, and partly to defective rainfall which has diminished the incidence on the third quarter. The contrast between the upper continental area (Punjab) and Southern India is, however, brought out still more clearly. From the statement just given, moreover, the Hill Stations are excluded; these are occupied almost exclusively during the seven or eight months, from the end of March till the middle of October.

TABLE XXXIV.

Seasonal Incidence of Enteric Fever in Hill Stations, 1895-98.

	Quarterly percentages.			
	January to March.	April to June.	July to September.	October to December.
Bengal Hills	12·9	65·1	20·7	1·2
Punjab Hills	2·4	49·6	45·8	2·1
India (All Hill Stations) ...	5·1	43·2	41·5	10·2

The hot weather sets in earlier in Bengal than in the Punjab, and the men consequently assemble in the Hill Stations of the former Command at an earlier date; with this we may note the fact, in passing, that the rise in the Enteric curve takes place a month earlier in Bengal than in the Punjab, the disease is therefore present in most of the Plains Cantonments before the men leave for the Hills.

The more precise monthly incidence will be discussed with more advantage in dealing with the separate geographical groups: here we may merely summarize briefly the facts for the Commands. As regards those in the Northern area we find the disease beginning to increase at the end of February in Bengal and a month later in the Punjab, and it reaches its maximum prevalence in April in the former area, and in May in the latter. Then follows a sudden decline during June and July which is common to both, to be followed by a second period of increase beginning, for Bengal in August, reaching its highest point in September and falling again in October; in the Punjab there is also a second increase in August-September with a fall in September-October, but it is proportionately much smaller and of briefer duration than that of Bengal at the same period. Finally, in both Commands there is a third rise in the curve in November, which continues through December to culminate in January and to fall in February. In Bombay and Madras the notable features of the curve are a comparatively small, but distinct rise in April (extending into May in Bombay), and then, after a decline, we get the period of maximum prevalence in the monsoon months, July to September, with a tendency to persist into October in the former area, which also, frequently, exhibits a third small rise in January. These remarks are based on the records of cases when coming under treatment and must be read in the light of the fact that two, or probably three, weeks elapse between the time of infection and that of recognition and record.

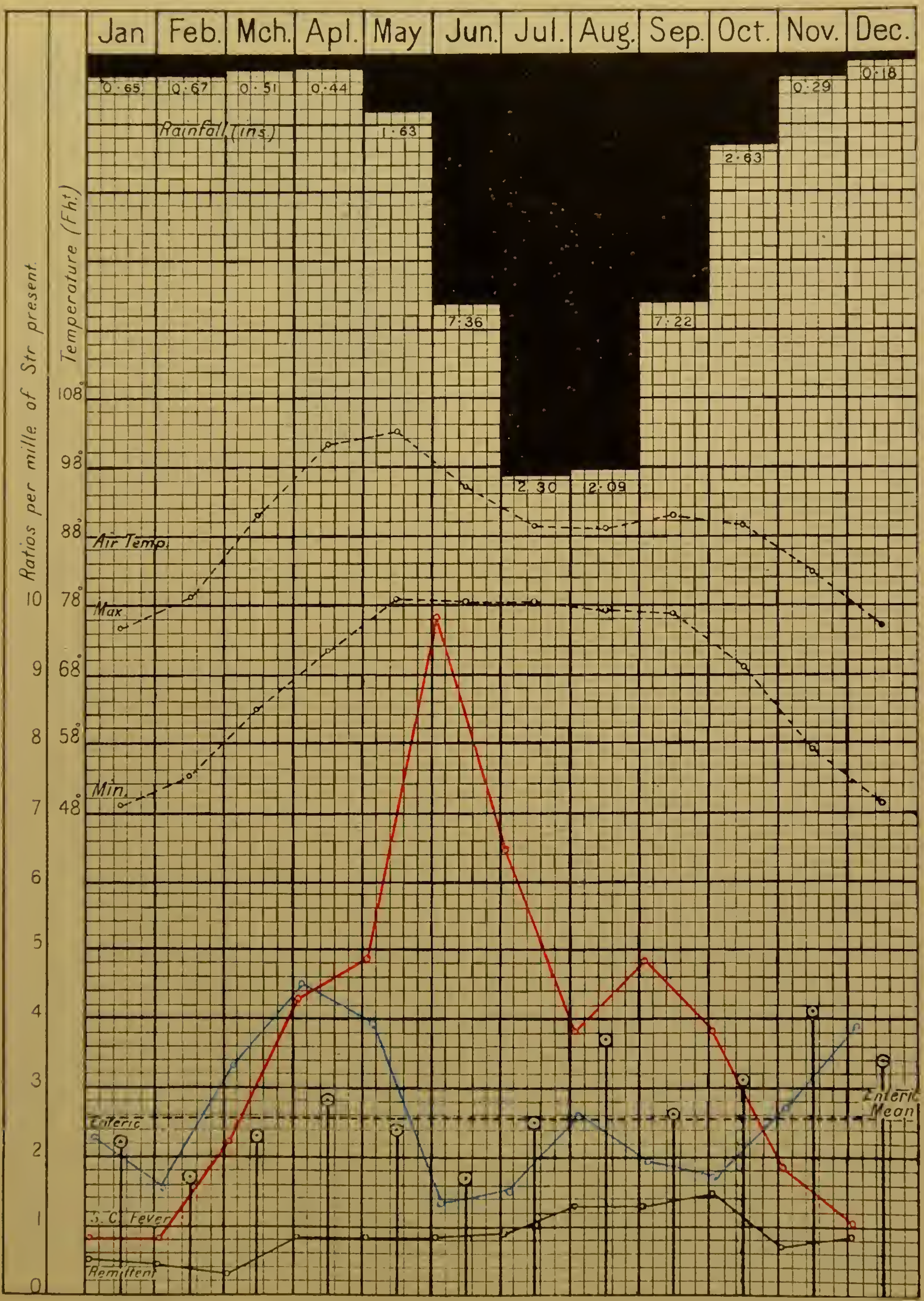
With these general considerations before us we may pass on to a closer analysis of the facts as displayed in the more definite geographical groups into which the Commands are sub-divided, and we must leave the charts to speak for themselves as regards the minor details, reserving the space at command for the discussion of the broader contrasts and the relation of the various factors to the issues disclosed.

Charts of the Geographical and Meteorological Groups.—A reference to the map of the local incidence of the disease (page 139) will give a clear idea of the relative extent and distribution of the areas into which the country has been sub-divided on the basis of the distinguishing physical characteristics. The geographical position of each area and the cantonments grouped therein are further indicated by its title, and the list at the head of each chart. It has, however, not been deemed necessary to give a chart for each of the twelve groups, as it will suffice to depict the data for the endemic area and one or two groups in the non-endemic area for contrast and comparison. The meteorological data were kindly furnished by the Meteorological Reporter to Government, and the curves of the different diseases represent the ratios which the admissions to hospital in each month bear to each thousand of the average strength present during the month; the rates are worked on the aggregate for the decennium 1890-99, this being the period for which the figures are most reliable, and in which the prevalence of Enteric Fever reached its highest point; it is, moreover, free from the disturbances caused by the indirect results of the Boer war in the period of the "decline" already discussed. The brief summary of the meteorological phenomena and of the course and characteristics of the different seasons, given in the preceding chapter, will enable the reader to appreciate more readily the significance of the order of events and the factors in operation.

We may now proceed to summarize some of the broad indications which the series of charts afford. We recognize throughout a characteristic treble rise in the Enteric curve associated with the hot dry, the hot wet and the cold dry seasons, respectively, but the proportional extent of each rise varies considerably in each area, and marked differences are disclosed when the

CHART No. VII.

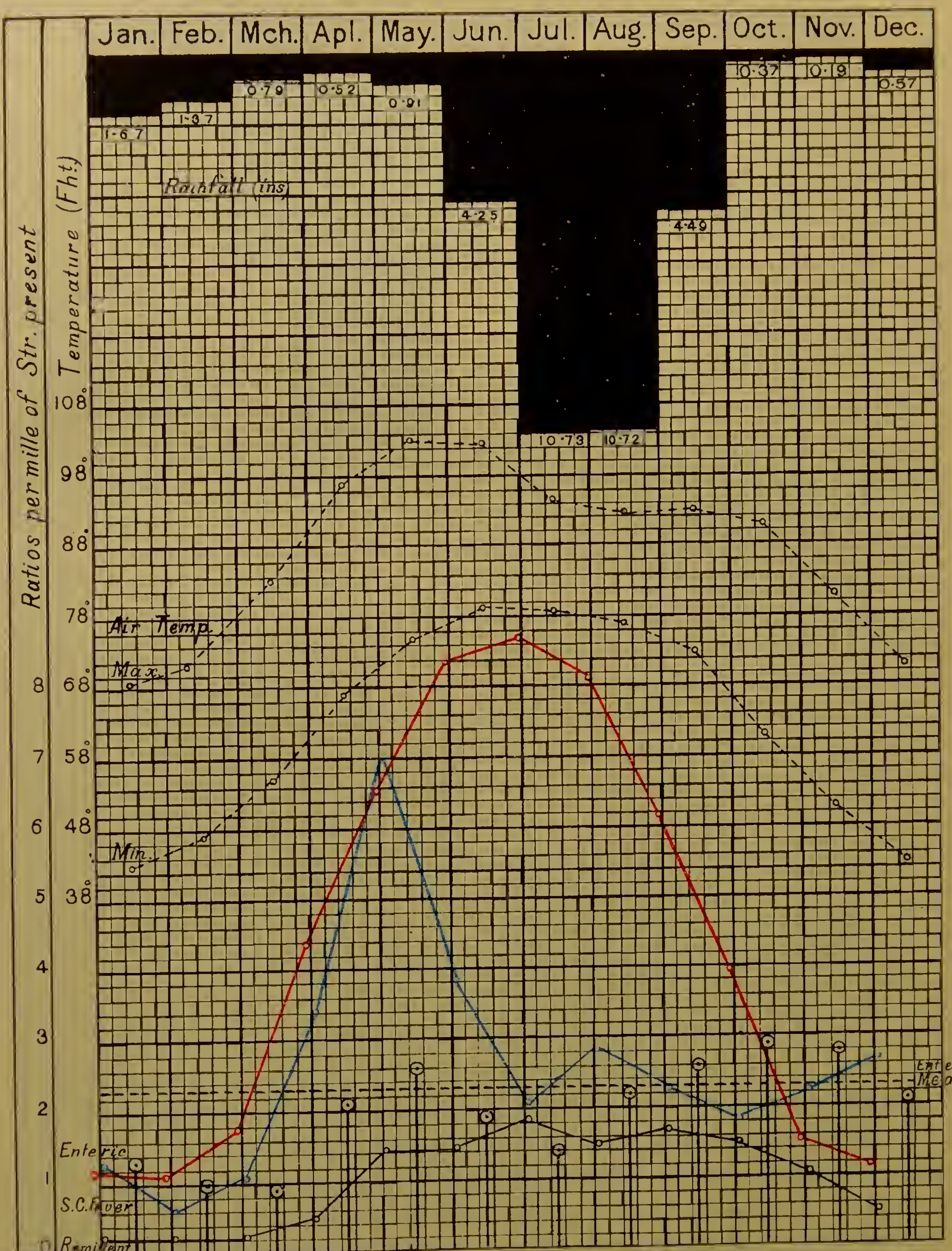
GROUP V. GANGETIC PLAIN. DINAPORE, BENARES, ALLAHABAD, FYZABAD, SITAPUR, LUCKNOW, CAWNPORE, FATEHGARH.



Blue line, Enteric; Red, S. C.; Black, Remittent; Vertical lines, Dysentery

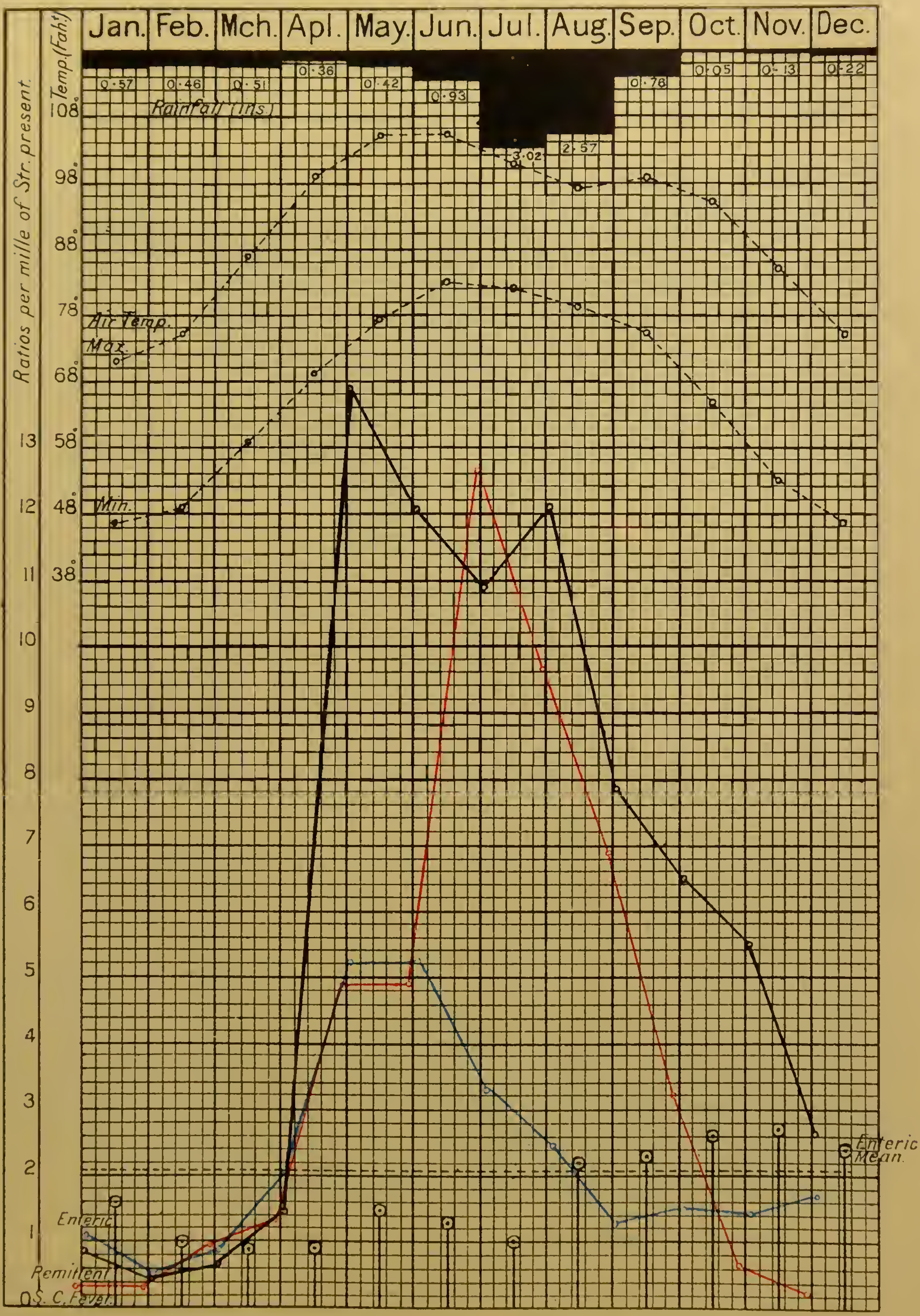
CHART No. VIII.

GROUP VI. UPPER SUB-HIMALAYA. SHAHJEHANPUR, BAREILLY, RURKI, MEERUT, DELHI, UMBALLA, JULLUNDUR, FEROZEPORE, AMRITSAR, MIAN MIR, LAHORE, SIALKOT, RAWAL PINDI, ATTOCK.



Blue line, Enteric ; Red, S. C. ; Black, Remittent ; Vertical lines, Dysentery

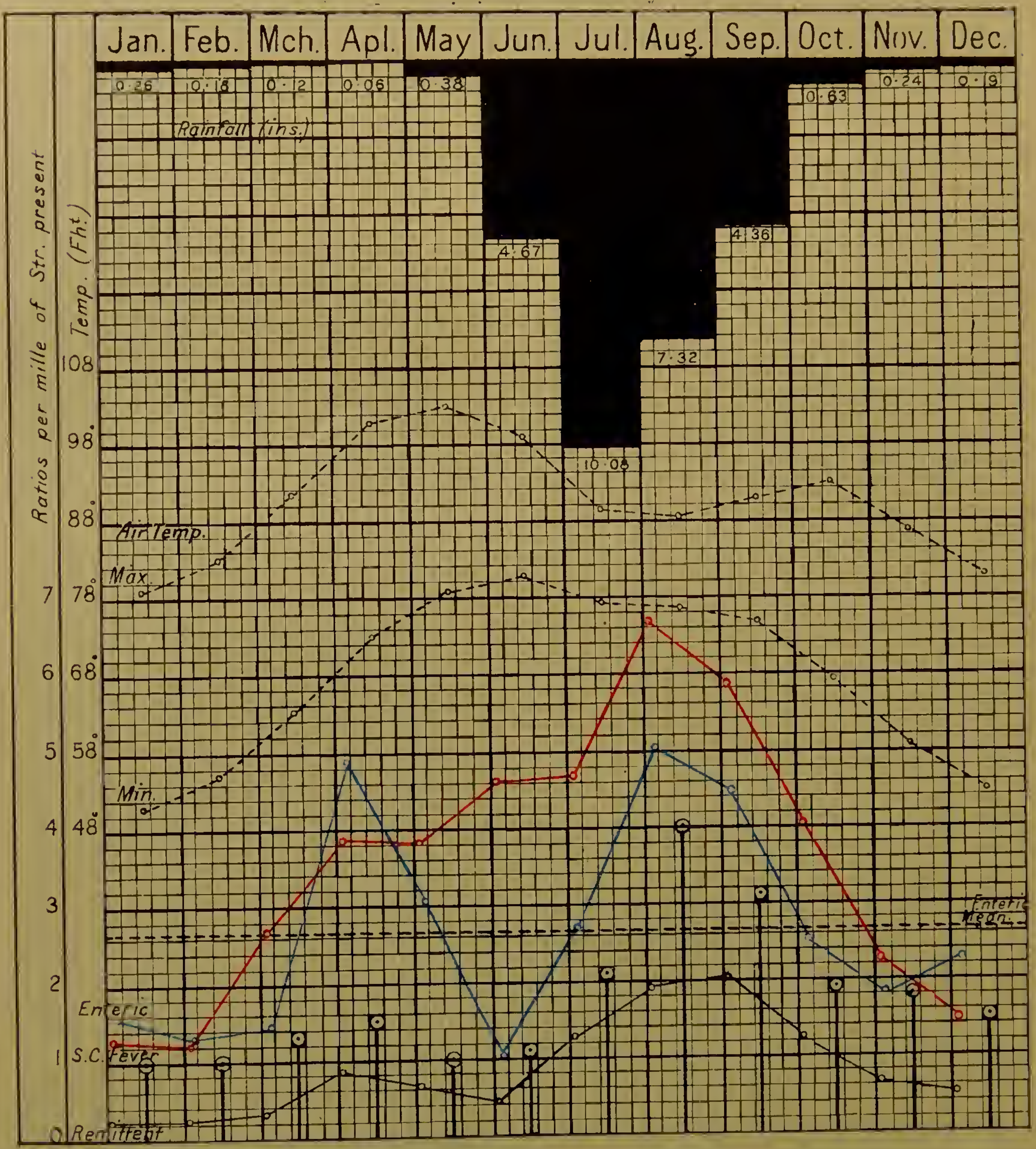
GROUP VII. N.-W.-FRONTIER, INDUS VALLEY. NOWSHERA, PESHAWAR, MOOLTAN, &c.



Blue line, Enteric ; Red, S. C. ; Black, Remittent ; Vertical lines, Dysentery

CHART No. X.

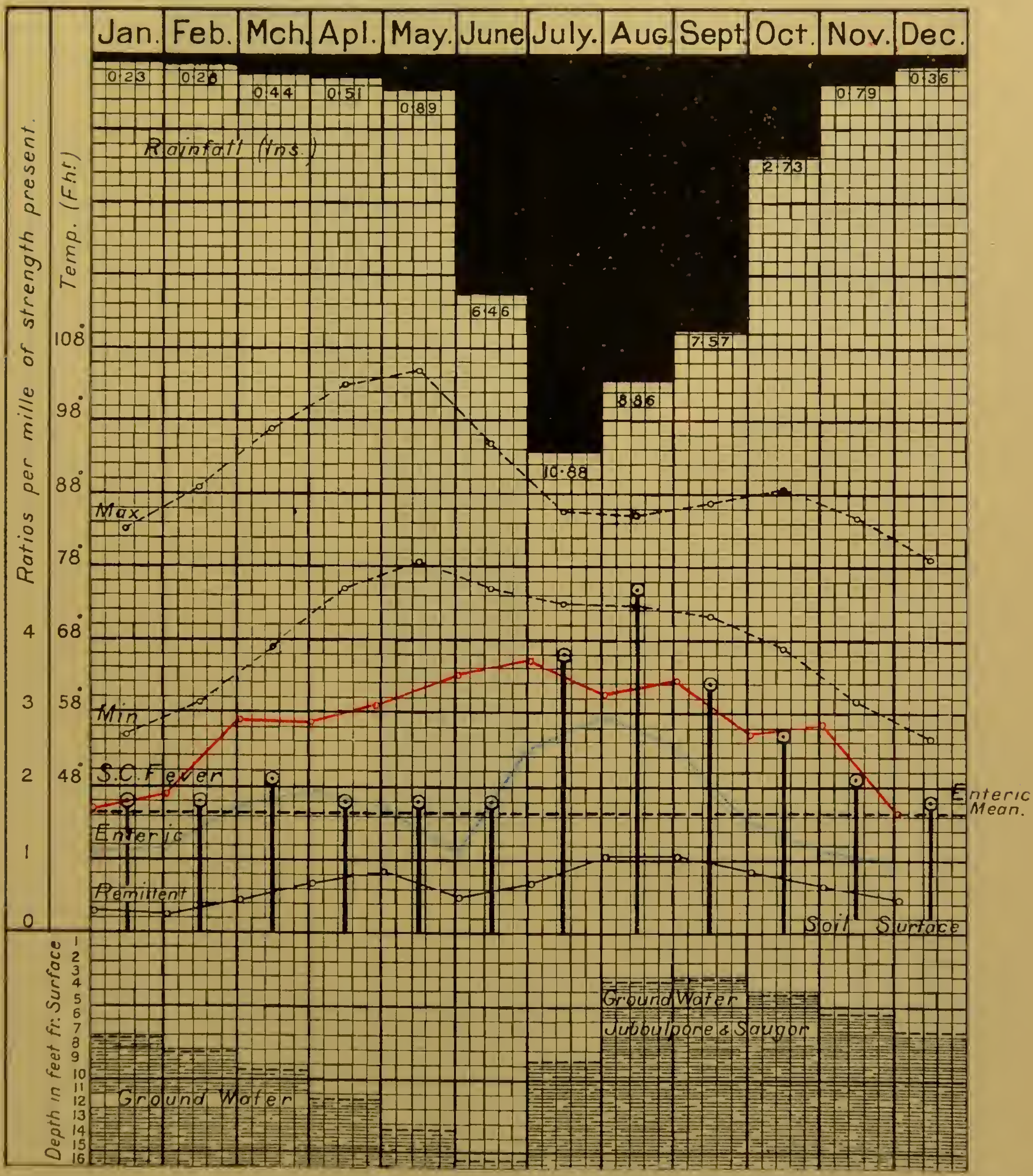
GROUP VIII. CENTRAL INDIA.. MUTTRA, AGRA, JHANSI, NOWGONG, INDORE, MHOW, DEESA, AHMEDABAD.



Blue line, Enteric ; Red, S. C. ; Black, Remittent ; Vertical lines, Dysentery

CHART No. XI.

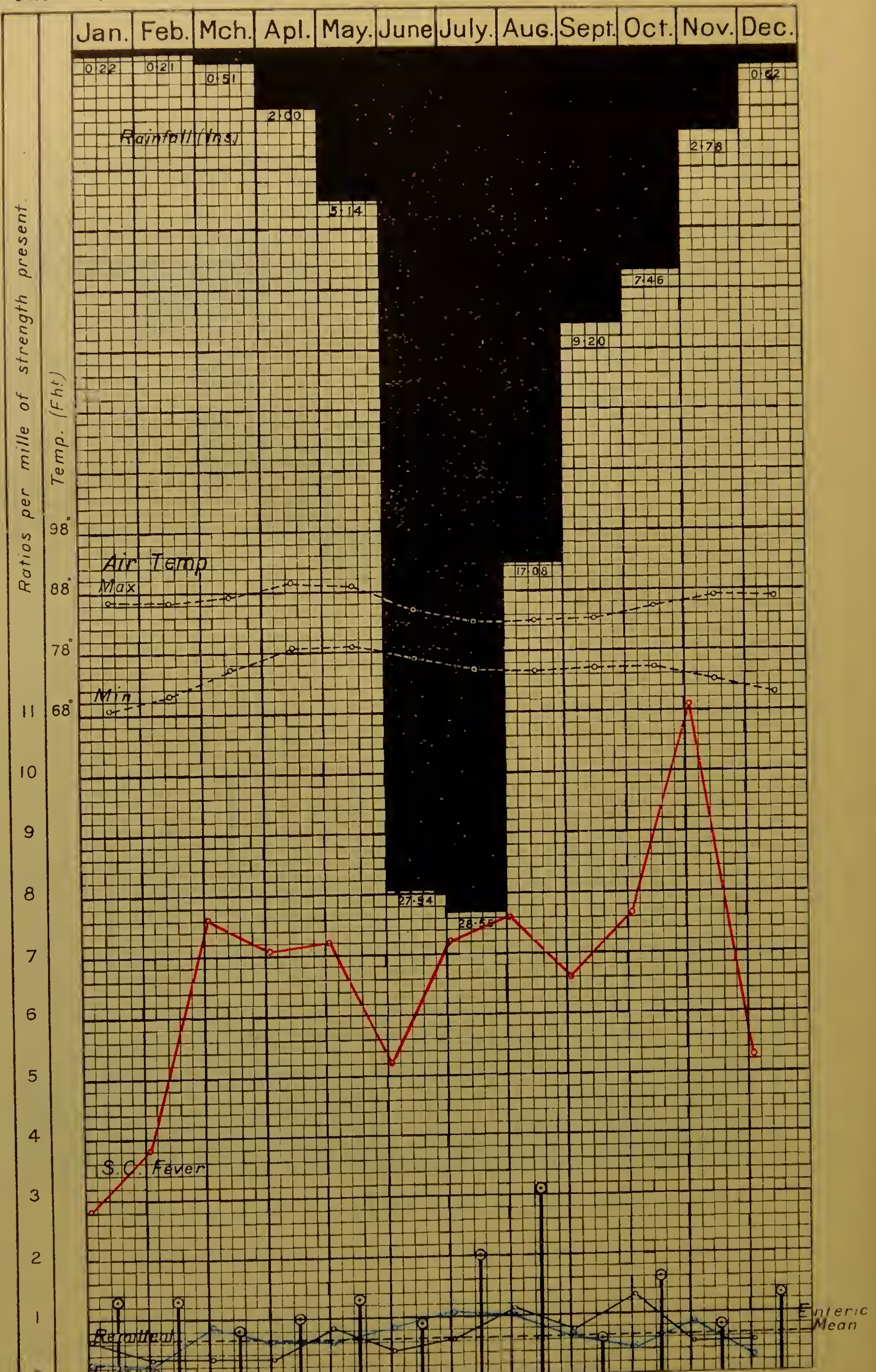
GROUP IX. DECCAN. SAUGOR, JUBBULPORE, SECUNDERABAD, POONA, KIRKI, AHMEDNAGAR, BELGAUM.



Blue line, Enteric; Red, S. C.; Black, Remittent; Vertical lines, Dysentery

CHART No. XII.

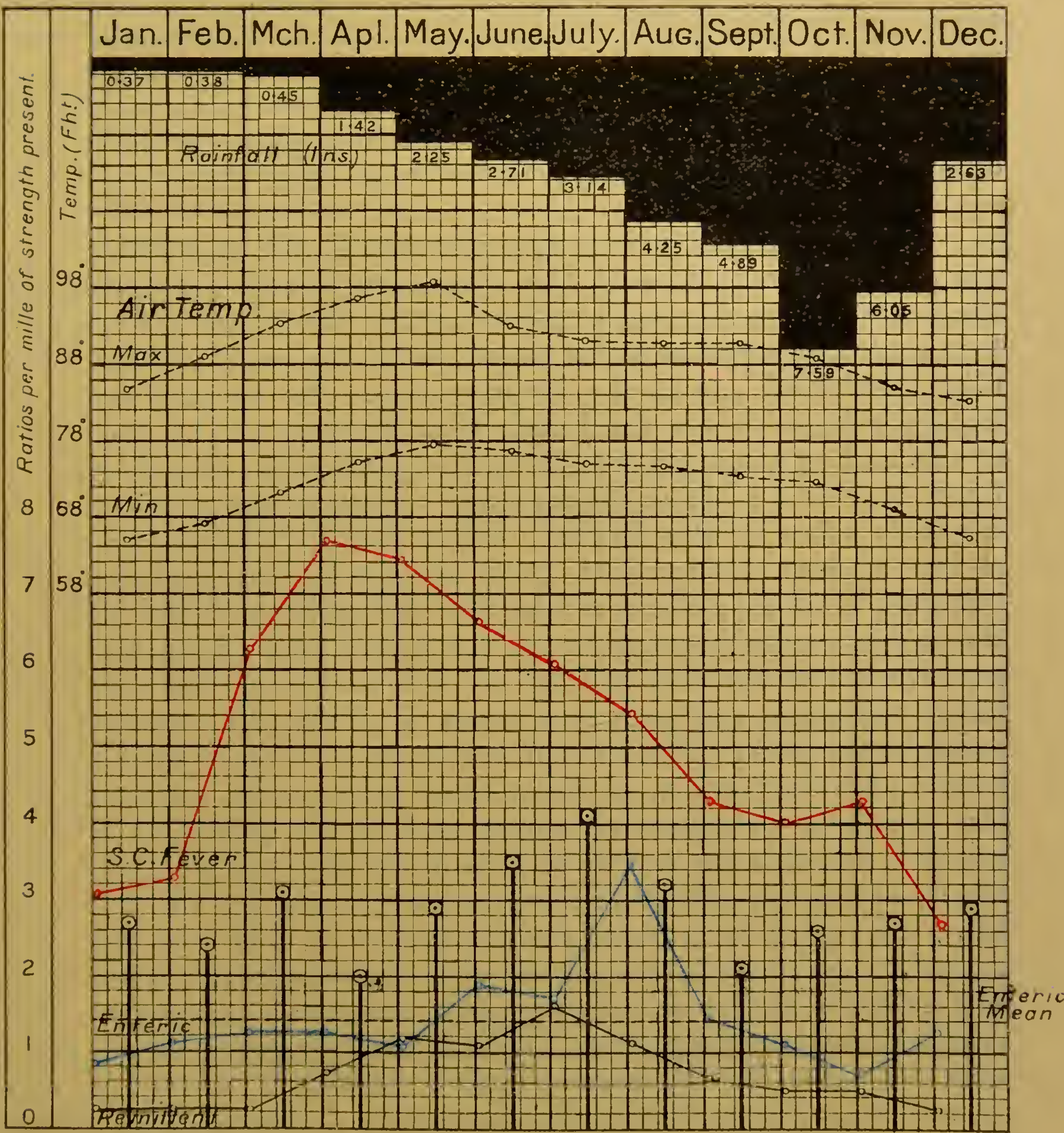
GROUP X, WESTERN COAST, BOMBAY, CANNANORE, CALICUT, MALLARAPURAM.



Blue line, Enteric ; Red, S. C. ; Black, Remittent ; Vertical lines, Dysentery.

CHART No. XIII.

GROUP XI. S. INDIA. BELLARY, BANGALCRE, TRICHINOPOLY, MADRAS, PALLAVERAM.



Blue line, Enteric ; Red, S. C. ; Black, Remittent ; Vertical lines, Dysentery

respective seasonal *fastigia* are compared *inter se.* This is brought out by observing the relations between the *fastigia* and the mean monthly rates, represented by the horizontal broken lines. The only remarkable aberration is that presented by Group VII., in which the monsoon rise is absent, but note that here the rainfall is very small, the ground-water is, generally speaking, more than 80 feet from the surface and does not fluctuate under the influence of the rainfall. On this point see chart for Group IX. whereon the levels of the ground-water at two of the stations have been plotted, merely as a general indication of what occurs under ordinary circumstances in the endemic area ; it is obviously impossible to give, on one scheme, exact data in this connexion for a large area including widely scattered cantonments.

In the true continental area (Groups V., VI. and VII.), we see the greatest prevalence of the disease definitely associated with the hot dry season, closely following the rise of the air temperature and the increase in its range, while the rainfall and humidity combined are at the lowest point. As we pass from the Gangetic Plain (V.) to the North-West Frontier (VII.), the periods of rise and of acme are seen to be deferred from March-April to April-May and to June, respectively : observe the relations of the monthly rates to the means. When the air temperature is still at its highest (for account must always be taken of the period elapsing between infection and the recognition of the disease), the incidence declines suddenly, but is still well above the mean, and then with the *first* rainfall of the monsoon, the curve falls below the mean, and in typical cases (V , VIII., IX.) to the lowest point in the year. The second access occurs one, or two, months later in different areas, as determined apparently by the date of the previous sequence of events and by the period of greatest rainfall, which is the month of July in the endemic area, and thus the monsoon rise culminates in August (Groups V., VI , VIII. and IX. ; the probable cause of the aberration in VII has been discussed.) As regards this second rise we note that it is relatively and actually higher as we pass from the true continental area, through the transition area (VIII.) to the Peninsular Group (IX.), where it assumes the most marked character of the annual curve. The incidence then declines again in September to reach a second minimum below the mean in October or November ; and thence ensues the third or winter rise with the culmination in December, which begins to subside in January to fall to the third minimum in February.

We need not pause to follow the order of events in the non-endemic area (X and XI.) for the same characteristic features are demonstrated, though in very different relative proportions, the key to which must be sought in the contrast presented by the physical factors —meteorological and telluric--to be discussed later. It may, however, be noted in passing that it will be shown subsequently that the period of greatest prevalence (June to August) is definitely associated with the pollution of the water-supplies under the influence of the rainfall, as demonstrated by the calendar of their microbic contents. The salient indication afforded by the charts is that in all the different areas the same characteristics mark the curve of incidence, but in varying degree, as a result, we must assume, of the varying force and direction of the more or less common physical factors in operation.

We have, so far, been dealing with the morbidity, and it is necessary to show that the mortality follows the same course: it will suffice to give the facts for the hot weather and monsoon periods, respectively, so far as the endemic area is concerned.

TABLE XXXV

Proportion of Mortality per cent. *of total during the Hot weather and Monsoon periods.*

	March.	April.	May.	June.	July.	August.	September.	October.
Group V ...	...	36	...	...	...	21	...	...
,, VI ...	...	...	42	...	...	21	..	...
,, VII ...	..	...	...	61	...	...	...	...
,, VIII ...	...	29	...	...	...	35	...	..
,, IX ...	...	...	25	...	...	...	49	...

We may now deal very briefly with the indications afforded by a comparison of the three Fever curves—Enteric, Simple Continued and Remittent, as a supplement to the remarks on diagnosis in Chapter II. In all but one Group (VII.) the Enteric Fever curve occupies an intermediate position between that of Simple Continued and that of Remittent. Next, we see that with some general correspondence in the rhythm of seasonal prevalence, which is most remarkable in Groups V., VI., VIII. and IX.—the typical endemic area—there are some notable contrasts in the respective periods of maximum incidence. One cannot study the course of the curves without being impressed with the suggestion that there are factors in common which appear to influence alike, if in different degree, the occurrence of all three varieties, including the more ephemeral and severer forms of Continued Fever. There is everywhere a fairly simultaneous rise from a minimum in the cold weather, when Enteric is, as a rule, relatively the most prevalent of the three, but in the case of Simple Continued and Remittent the impulse is longer sustained to reach the respective maxima during the first heavy rains of the monsoon when the Enteric curve has fallen to below the mean. And, indeed, we may summarize the net results by saying that, with minor but very suggestive fluctuations corresponding more or less closely with the distinguishing characteristics of the Enteric curve, the marked tendency of Simple Continued and Remittent is towards one period of greatest prevalence, *viz.*, that of the monsoon ; and further that as between Simple Continued and Remittent, the tendency is for the latter to maintain its access more steadily and to a later date. In the present state of our ignorance regarding the pathology of the morbid states included under these two designations, and without discounting the results of future research, we are doubtless justified in reading the facts as indicating that to some small but inestimable extent the three fevers are, if not etiologically and pathologically one, favoured to some extent by the same conditions, but that to Simple Continued and Remittent must be ascribed, in their typical manifestations and in largest measure, a malarial origin. The light thrown upon the question by the seasonal incidence of the mortality, serves as far as it goes to confirm this provisional view. Simple Continued Fever is very rarely fatal, but when it is, it is generally found to require re-classification as true Enteric. But in regard to Remittent and Malarial Fevers we find that there is a definite rise in the mortality curve in the April-June quarter, and then, after a small decline for two months, a second greater rise which culminates in October, but which is maintained at a high level till December, to subside to the lowest point in February and March. The definite increase of both morbidity and mortality in the hot dry season, though not conclusive, is somewhat suggestive of a diagnostic refinement which is not wholly justified, and possibly a proportion of cases of true Enteric escape recognition.* It is noteworthy that the case-mortality of Enteric is, as a rule, highest in the continental area in the hot weather (Bengal) and in the monsoon period (Punjab), whereas the disease is most fatal in the winter and autumn quarters in Southern India, facts which are at least suggestive when the periods of greatest prevalence of Simple Continued Fever in the different areas are compared, *e.g.*, compare the curves in Groups V. to IX. with those in X. and XI.

TABLE XXXVI.

Enteric Fever.

Case Mortality per cent. by Months and Quarters, 1898-1902.

Commands.	Jany.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
Bengal ...	23	17	16	22	36	36	33	22	25	33	14	19	= 24
		19			29			26			20		
Punjab ...	33	40	27	16	34	42	37	34	27	36	16	29	= 30
		33			30			33			26		
Madras ...	30	19	39	23	29	17	16	36	38	20	18	22	= 26
		31			22			30			20		
Bombay ...	19	32	28	25	27	24	22	22	30	32	28	28	= 26
		26			25			25			30		
India ...	26	26	23	20	33	35	27	26	29	32	20	24	= 27
		25			28·5			27			25		

Having regard to the unequal distribution of the disease at different periods of the year, to the length of the incubation period and to the duration of the attack, we may not associate the deaths in any one month with the infections acquired in that month, and consequently the figures for the separate quarters have also been given. As regards India as a whole, the cases are more fatal in the two middle quarters, which may probably be attributed, chiefly, to the more exhausting climatic conditions of the hot and rainy seasons, and, partly, to non-recognition of cases returned under the heads of other fevers which are most prevalent at this time. But everywhere, save in Bengal, the case mortality is at its highest also in one of the two cold weather

* We say "possibly;" the suggestion is not so clearly borne out on a closer examination of all the facts. We shall discuss the point in Chap. IX., and show that there is evidence of a rise in the prevalence of true Malarial fevers in the hot-weather period, synchronous with a notabl increase in the prevalence of *anopheles* mosquitos.

quarters (the Punjab and Madras in January to March, Bombay in October to December), and it is possible that this may indicate failure in the recognition of cases of the disease masked under the clinical features of other anomalous forms of "fever." It is just the period when new men are arriving, when inter-station movements are most frequent and when the troops are most exposed to the influences of the alien environment in manœuvres, camps, &c., all circumstances rendering the recognition of light atypical cases especially difficult; at the same time the effect of complications on the fatality must be borne in mind.

We may conclude that, on the one hand, there is sufficient evidence of an uncertain measure of unjustifiable discrimination between the three classes of fevers, whereby true Enteric is lost to the account, but, on the other hand, it is also clear that we have, for the most part, to deal with very different pathological entities. And, further, that while there are closer affinities between Simple Continued and Remittent Fevers than between either of these forms and true Enteric, it is probable that the former terms do not connote the same pathological states in all the areas and that each, everywhere, represents more than one morbid affection, though Malaria, in one or other form, accounts probably for the majority of the returns under these heads. It has been suggested by more than one observer that the special prevalence of true Enteric in India is associated definitely with only one season of the year, *viz.*, that of the spring and hot dry months, and that the rise in the monsoon is due to the inclusion, under the head of Enteric, of Malarial and other Remittent forms, but this view cannot be sustained when regard is paid to the evidence of *post-mortem* examinations, to that of the case mortality and to the facts of the seasonal incidence in different areas, and notably the tendency to the transfer of the period of greatest prevalence to the monsoon months as we pass from the continental to the peninsular area. (See foot-note, page 187.) If there were any grave diagnostic error in the returns since 1890, we should expect to find evidence of a tendency to return the doubtful cases of Continued or Remittent Fevers as Enteric when the typical form of Enteric is most common, and *vice versâ*; the effect would be to exaggerate the increase during the periods of greater prevalence, and conversely. But the evidence of the charts scarcely bears this interpretation, at any rate, without considerable qualifications. And we do not find any grave discordance between the fluctuations in the admission rate (which is admittedly open to diagnostic errors) and those of the mortality rate which is far more exempt from the same sources of doubt.

It remains to refer briefly to the inter-relations of the curves of Enteric Fever and Dysentery, which must be deemed very striking. Here, indeed, we appear to be upon the track of an influence which operates similarly and simultaneously to favour the occurrence of both diseases, which is no matter for surprise in view of their etiological affinities. It is quite unnecessary to dwell upon these in detail, and the charts may be left to speak for themselves ; we may merely claim that a comparative study of the epidemiology of the two morbid states will serve to elucidate and confirm the main positions herein contended for. Of the two marked maxima which the Dysentery curve displays, the second and larger is very definitely associated with the monsoon period ; there is, in fact, a close correspondence between the incidence of the rainfall and of the disease after the former is well established, the first precipitation operating, as in the case of Enteric, to diminish the morbidity. It is also to be noted that in the years of excessive monsoon, this maximum is enhanced, and *vice versâ,* deficient rainfall is accompanied by a lower Dysentery rate at this period. With heavy tropical precipitation on a foul and permeable soil, with a high and rapidly rising ground-water, the incidence reaches its maximum ; but where the rain is light and intermittent and the ground-water far below the surface and scarcely subject to fluctuation under the influence of the monsoon (as in Group VII.), the disease is less prevalent and the curves display a less sensitive correspondence. In Europe it is now well recognized that a cool and rainy summer is associated with a great diminution in the morbidity from bowel complaints, whereas abnormal drought is accompanied by their excessive prevalence ; the phenomena in India must be regarded in the light of the distinctive physical factors in operation, to which factors any apparent divergence from European experience must be referred. That experience receives abundant confirmation in the order of events displayed in the hot weather and during the first rainfall, but with the full establishment of the monsoon, conditions are set up which rarely find a parallel in Europe, and in which the rainfall assumes an entirely different rôle. The subject of the course and decline of the incidence of bowel complaints has been discussed in Chapter II. ; in the case of Dysentery the decline may be said to amount to nearly 50 *per cent.* during the last 30 years, and the question arises as to the possibility and extent of confusion of this disease with Enteric Fever in the earlier records. On this a definite statement, affirmative or negative, is not justified by the data at disposal, but it may be noted that the mortality rate (Dysentery) has declined *pari passu* with that of the morbidity, the case-mortality in the successive decades maintaining a remarkably steady level throughout, at about 3·5 *per cent.* These facts, when taken along with the rise in the morbidity and the decline in case-mortality of Enteric Fever and with the pronounced similarity in the seasonal incidence of the two diseases, may perhaps be held to have some significance. (See Chap. VIII.)

Having thus arrived at the broad results which exhibit such striking contrasts in the seasonal incidence of the disease in the different areas and localities, it remains to indicate as briefly as possible some of the chief determining factors in operation. The sketch of the physical environment given in Chapter III., to which the reader is referred, together with the considerations adduced in connexion with the local distribution of the disease, have enabled us to mark off certain areas of greater and less prevalence which we may designate as endemic and non-endemic areas respectively; the characteristic and distinctive features of both have been contrasted, and the details afforded by the charts will complete the picture. Bearing these facts in mind we have now to indicate their bearing on the phenomena of varying seasonal incidence, and, as before, we shall endeavour to interpret these in terms of the three etiological factors: the human host, the germ and the environment. If we deal, first, with the more salient and striking of these phenomena, the minor and apparently aberrant ones will present less difficulty, though it cannot be pretended that all admit of conclusive elucidation. We may examine the phenomena of the three maxima or rises in the Enteric curve which are associated with the hot, the wet, and the cold seasons, respectively, and then deal with the contrasts these maxima present in the endemic area, *i.e.*, in the northern or "continental," and in the trans-Vindhyan table-land subdivisions of that area.

First, as to the environment; the physical factors of which account has to be taken and the action and interaction of which have to be borne in mind in much the same way as a "hand at whist," are briefly:

(1) the Rainfall and humidity, its amount and character, and with this, the periods of drought, relative or absolute, intercurrent or continuous;

(2) the Temperature, its annual extremes (hot and cold seasons), its daily range, its interaction with the rainfall (inducing pre-disposing "chills" and other fevers);

(3) Soil, surface and subsoil; its physical and chemical qualities, as affecting the production of dust (action of temperature and winds) and in its relation to water, to rivers, to the surface precipitation and the subterranean sources; the periodic movements of these, surface scour and percolation, and the fluctuations of the ground-water, as affecting the water-supplies.

Account must be taken of the relations of the different soils to the hygroscopic moisture as well as to the grosser and palpable hydrostatic water, for beyond the general climatic influences on plant life and on man, we have to regard in all physical phenomena of the soil in its meteorological relations, the two-fold influence on the viability and the transport of the germ. Hence the factor of atmospheric and soil humidity has an important bearing on the local and seasonal incidence of any endemic disease, the germ of which has a faculty for saprophytic life however limited. These conditions of humidity, which vary with the structure (texture), composition and colour of the soil, have a direct relation to its temperature and fertility, *i.e.*, to the viability of lower vegetable organisms, and no greater contrast, in this respect, could well be afforded than that between a harsh coarse sand or lime (as seen in the extreme continental area) and the sponge-like, organically rich "regur," or "black cotton" soil, of the Deccan table-land. The bearing of these considerations will be apparent when we come to deal with certain contrasts in the seasonal incidence which characterize the endemic area. The data available in regard to these factors are to be applied to the phenomena in the light of the experience supplied by the course of other infectious diseases of the same category, notably Cholera, Dysentery and Infantile Diarrhœa, and in the light of the course of Enteric Fever itself in other countries, as in Europe, Egypt and South Africa, which has been described.

It will simplify matters to begin with the annual period of the arrival of the human host without special regard at this point to the question of the sources of infection, whether imported or already present in the environment. The circumstances under which the troops are transported to India have been fully described; for the past 20 years some 14,000 or 15,000 more or less susceptible subjects have been imported annually during the trooping season which extends from October to March, inclusive; an equivalent number has been despatched along the same route in the reverse direction during the same period, a considerable proportion having suffered from the disease or having been in more or less close contact with it. Here, then, on any theory of infection we have not far to look for a pronounced rise in the Enteric curve which should, *ceteris paribus*, vary in extent with the amount of susceptible *personnel* freshly exposed, and, indeed, as will be shown, this is precisely what is found to occur. Beyond this we should expect variations in this winter rise in locality corresponding to the facilities and abundance of infection (aggregation, traffic, &c.) and to the predisposing causes present, involving less or more complete physiological adjustment at the time. In many respects the non-endemic ("coast") areas with their damp tropical climate are more inimical to newly-arrived Europeans, at this season, than the more bracing atmosphere of Upper India, and we see a larger proportional rise in the winter curve of Enteric in the former.

It is also important to note that the winter months (November to January) are the period of manœuvres and camps of exercise when the troops leave cantonments for life in camp, the conditions of which are eminently favourable to the acquisition and spread of infection (see Chapter V.).

The reliefs and drafts travel up the main lines of communication, a single ship-load being frequently distributed to a dozen different cantonments, on the way to which the men occupy several rest-camps which have accommodated their predecessors and also the time-expired travellers homeward bound. Enteric Fever now appears in many of the stations, culminating, so far as the winter rise is concerned, in January, but persisting to a less extent through February, and the conditions are now preparing for the ensuing maximum which begins at the end of the latter month in the more eastern parts of the continental area, but later as we proceed westward. This gradual deferment in the onset of the rise at the commencement of the period of greatest prevalence in Northern India is the next striking feature of the seasonal incidence. If the returns from individual stations located along the Indo-Gangetic plain, from Barrackpore to Peshawar, be examined, this phenomenon is strikingly demonstrated, and it is a familiar and well-established feature of the epidemiology of Cholera and other hot-weather bowel-complaints. Now the order of all the natural phenomena, as determined by the physical conditions (climate, &c.), proceeds precisely in the same direction. There is scarcely any spring on the eastern side of the plain, and there the hot-weather period follows close upon the ill-defined "cold" season; farther west, we get a more definite interlude of spring (in March in the intermediate area), and a gradual deferment of the commencement of the true hot season which does not set in in the Punjab till about the latter part of April.

With this we see a corresponding deferment of all natural processes as exhibited by the agricultural calendar, a notable indication of which was provided this year (1905), when severe and abnormal frost prevailed in the spring, and caused immense damage to the rising crops in the central area (United Provinces), but had no chance of similarly affecting those in the Punjab to the west. This is of great interest and significance as denoting an unquestionable influence of the natural environment on the vital processes of the specific germ which, after all, is a low form of vegetable organism, and doubtless also on the human host and on the means of access of the one to the other.

The factors which control the phenomena of deferment, when their operation is reversed may surely be invoked to account for those of the rise in prevalence which now occurs and proceeds steadily to the maximum in April in the most easterly area, and in May further west; for the extent of the prevalence of the disease is more or less definitely associated, in time and place, with the extent of the development of the physical factors. Here, again, we see the analogy with Cholera incidence; the most definite endemic area of Enteric Fever, including the geographical groups V., VI., VII., VIII and IX., is precisely the area of greatest Cholera prevalence in its *epidemic* form, so far as the European troops are concerned. A comparison of the records with those of Lower Bengal, the so-called "home" of Cholera, will demonstrate this conclusively, and the seasonal incidence of the two diseases is identical. We need not discuss the etiological analogies and differences that exist between the two diseases, but both may serve to elucidate the problem before us; they are evidently under the control of the same predominating influences that mark the period of the year in question—great heat, a high range of temperature; a polluted soil which now encroaches, as dust, on the region of the respirable atmosphere and which, transported by the winds which now prevail, contaminates food and water-supplies in the most secluded places; the water sources at or near their lowest level and at the highest point of concentration; the great increase in insect life;—these are the main features of the situation which must affect the vital activities of both germ and human host and their mutual relations to the production of the results we see. And where these results vary in the epidemiological *facies* of the two diseases we may find indications of certain differences in the viability of the respective effective germs in external nature and in the ordinary means of their conveyance to the body of the host. Cholera in its epidemic form is almost a thing of the past in these cantonments; isolated ("contact") cases and restricted outbreaks, due probably to a polluted food supply, still occasionally occur, but it can scarcely be doubted, in the light of our present knowledge and the characteristic nature of the outbreaks, that, in former days, the chief source of infection was specifically polluted water. The attention devoted to the water-supplies in recent years has availed to control and to eliminate practically the disease in its epidemic form from our records, save in very exceptional instances. It is far otherwise with Enteric Fever, and this gives rise to, at least, two considerations; we must, on the one hand, look elsewhere than to the water-supplies exclusively for the sources and vehicles of infection, and, on the other hand, in recognizing the etiological and epidemiological analogies of the two diseases, we must not exclude the water-supplies from a judicious view of their true rôle, if only on account of our ignorance of the differences in the viability of the germs. If that of Cholera does not gain immediate access to a water source it will probobly die out under the conditions of the hot-weather in our endemic area (Enteric); the sources of Enteric Fever infection are far more abundant and more constantly present and the germs find their way to the surface soil of the immediate surroundings in untold numbers, constantly reinforced, and here they probably find conditions suitable, or not inimical, to their viability for considerable periods, *e.g.*, on account of the presence of nitrates and other pabulum so abundant at this season: the requisite moisture being always available where fæcal matter is deposited. From here their effectual access to a water source is frequently only a question of time and some favouring circumstance,—such as wind-borne fæcal dust, flies, or, more indirectly, by human traffic, as from trenching ground or latrine to the well or reservoir or barrack receptacle: the effects of the monsoon rains will be considered later.

Meanwhile, to pursue the main subject, while the disease is appearing in increasing amount, in most cantonments of the area in question, *i.e.*, in March and early in April, according to the locality, a large number of men are sent to the Hill stations, as to the course of the disease in which, we need only say here that it appears to have very little, if any, relation to seasonal changes, which is in marked contrast to the phenomena of the plains. Here with the infection present, the predominant influence is the presence and aggregation of susceptible subjects, whose absence from the plains will, so far, affect the further course of the disease in the latter, both as regards time and place. We must consider the disease in the Hills as depending largely on infection acquired in the plains, and as a special manifestation of the plains' incidence, a point to be dealt with subsequently. The absence of any marked seasonal influence on the course of the disease in the Hills is a striking fact which, if only negatively, supports the inference of a distinct climatic influence in the plains, and it is to be explained, doubtless, by the absence in the former of the distinctive tropical conditions which characterize the latter, especially at this season.

From what has been said of the conditions prevailing during the period of the hot-weather maximum in the northern area, we may perhaps recognize analogies with those of the later summer and autumn maximum of European experience; it is the period of harvest and of autumnal fruition and decay, when natural processes culminate and pause at rest before the second annual cycle is inaugurated by the rains; this double rhythmical cycle in the tropics must always be taken into account in epidemiological problems.

Proceeding with the course of events, we now come to the decline of the curve in June and July, but the latter part of the second of these months must be considered to be concerned in the infections which furnish the cases for the third rise in August. This June decline which must be referred to a diminution of infections in the latter part of May, is remarkably sudden and constant, but the disease is only in abeyance and takes a more sporadic form, while "Simple Continued" fevers maintain and even increase in their prevalence. Whatever be the legitimate inference from these facts, it is scarcely possible to doubt that there are influences which now operate to control, if not to alter, the *facies* of the disease.

This controlling influence would appear to extend over nearly two months, *viz.*, from the latter part of May to about the middle of July. During this time the physical conditions are certainly not uniform, but in all epidemiological phenomena we have to take account of the host as the chief source and disseminator of infection. And, further, when abundant sources of infection are present in the case of a disease largely spread by contact, the effect of a controlling influence of the environment will not take effect forthwith. We are, then, doubtless justified in looking to the culmination of the summer temperature and drought (*in combination*) as furnishing an influence inimical to some link in the disease process, and very possibly to the viability of the germ in external nature. The effect of sunlight and heat at this time must render the chances of life of microbic organisms very precarious; atmospheric temperatures maintained for many hours daily at 150°, or more, must render most loose soils and rocks sterile, for when the thermometer in the air stands at 90° only, the temperature of quartz sand one inch below the surface will rise to 126°, and that of ordinary garden soil to 114°; the results are manifest in the abeyance of all vegetative life at this season in India. With this, account must be taken of the rapid and excessive range of temperature owing to radiation after sunset, and altogether, the physical forces now in operation are disinfectant to a degree that leaves little chance of viability to the lowest floral organisms. Most of the mediate sources of contact infection must now be cut off and dissemination must depend on the more precarious chances of direct contact. (See remarks on the influence of dust and on the conditions which influence the life processes and propagation of flies, Chap. VII.)*

The hot season merges into the transition period of preparation for the monsoon, the rains commencing in the eastern area in the latter part of May, owing to the earlier onset of the current in the Bay of Bengal, but the first precipitation is deferred in Upper India (further west) for nearly a month. But the whole plains area up to the Punjab is subject to the altered conditions which accompany the preparatory disturbances set up by the Bay current; the strong westerly winds give place to calms, to shifting breezes or to easterly currents; humidity is increased and there is occasional rain ("Chhota Barsat") some two or three weeks before the monsoon proper sets in; and, finally, there is a marked decrease in the daily range of temperature. In the last third of June the monsoon breaks and is well-established in July; all the last mentioned conditions are accentuated and we get the annual deluge which changes the face of the land from a parched desert to fertile fields or tropical "jungle," according to the area and to the extent and persistence of the rainfall, which diminish as we pass from east to west. The conditions now established are synchronous with the third

* An instructive analogy is to be found in the seasonal epidemiology of Plague.

marked rise in the Enteric curve in this area, and that there is a definite causal association between the phenomena admits of little doubt. The evidence points strongly to processes developed in and through the soil upon the water-supplies, whether open streams or, for the most part, the ground-water ; the former are replenished by precipitation in the hills and by surface drainage along their course in the plains, the latter by percolation through the soil direct, or indirectly from the rising river tides, as in the case of the Nile cited. The results are, of course, affected by the physical conditions in time and place ; the amount and character (persistence or intermittence) of the rainfall, the nature of the soil and sub-soil, the level and extent of fluctuation, vertical and horizontal, of the subterranean lake underlying the great Indo-Gangetic plain. But throughout the area nothing is more remarkable than the definite impulse communicated to the ground-water within a week or two of the onset of the rains, unless it be the accompanying rise in the curve of bowel-complaints including Enteric Fever, allowing for the interval of the effective development of infection in each case ; dysentery and diarrhœa preceding the graver affection, while "Remittent" and "Simple Continued" fevers are now rising to their maximum prevalence.

This view of the influence of a mechanical interaction of the physical factors is certainly not intended to afford an exclusive explanation of the phenomena of disease prevalence at this time ; it is merely asserted that the sequence of events does not permit us to ignore it. And there are, obviously, other conditions set up at this time which must be held to promote the viability of the germ in the fullest sense of the term ; we need only refer to the decrease of sunlight, to the remarkable lowering of the temperatures of the air and soil to an "optimum" favourable to all lower organic life, and to the production of salts of nitrogen now in a most active stage.

In Chapter III. we have described the soil of the great plain of the North, and have marked its transition from the fine alluvial mud and clay in the east, through the slightly coarser loam in the centre to the still coarser sand and gravels of the Punjab, the surface rising gradually to a height above sea-level of over 1,200 feet in the course of 1,500 miles, while the ground-water level follows the line of the earth's surface, but at a gradually increasing distance therefrom ; thus, while in the Delta of the Ganges it fluctuates between practically surface soil level and a depth of from 8 to 10 feet, it is often more than 100 feet below the surface at the opposite extremity of the area, the region of river and canal irrigation. This, of course, is a broad general statement which requires modification in places, as the level varies with the heaping up of alluvial deposit between the river-courses, and with the interposition and strike of the deeper beds of impermeable clay which are found at different depths. There is also a distinction to be drawn between the conditions in the lower-lying lands contiguous to the banks of the rivers ("Khadar") and those of the main extent of the plain beyond ("Bhangar") which is more elevated. In the former the ground-water lies near the surface (10 feet or more) and oscillates with the rise and fall of the river ; in the latter the depth of the spring-level varies from 15 to 50 feet or more from the surface and is less obviously subject to the influence of the river than to that of the rainfall. Now the destination of all fæcal and urinary excreta by which the infective germ leaves the host is the soil in the neighbourhood of cantonments and also, to a large extent (owing to imperfect conservancy) within their limits, *e.g.*, around latrines and near barracks, and there can be little doubt that the conditions are such as to favour the viability, if not the multiplication, of the bacillus. It is ordinarily enveloped in fæcal matter and further protected from the action of direct sunlight by a covering of surface soil, which must often be more or less sterilized by previous exposure to the intense dry heat by the method of preparing the trenches beforehand. The requisite moisture is always present in fæces and urine, and we know that the presence of nitrous and nitric salts afford a good culture medium for the germ. All the conditions which favour nitrification exist, and more especially before the full onset of the rains seals the surface apertures of the soil and excludes the necessary oxygen, but even then we may expect the reduction processes which accompany putrefaction to furnish nitrites and nitrates as by-products. When the tropical precipitation occurs, soil impurities, organic and inorganic, are flushed into the surface water-sources and into the deeper layers of the soil. Clay has a special affinity for foul organic products and hence a clay subsoil, with which we have to deal in this area, forms an efficient nidus for their retention and provides a special danger of pollution to the ground-water lying thereon. And apart from the defined stratum of clay at varying depths, we have also more discrete and scattered deposits mingled with the loam and sand in the upper layers. But it is, doubtless, seldom that specific germs are effectually and directly conveyed by the downward percolation of the rain-water to the ground-water, the physical and biological processes effected in a few feet of alluvial soil being opposed to this, save in exceptional circumstances. The first effects of rain are to wash the soil impurities down beyond the influence of the subsequent surface scour ; if the soil is very porous and the level of the ground-water high, succeeding rain may gravitate to the water-stratum which becomes a reservoir for these impurities, but otherwise, it is chiefly to the rise of the ground-water itself that we must look for this depurating action in co-operation, of course, with the effects of percolation from above. We may note, in passing, the practical importance of sub-soil drainage in keeping down the level of the ground-water below the depth to which surface impurities can range ; also, the advantages of deep artesian wells which tap the ground-water below the level of the first clay stratum and beyond the area of soil pollution ; and, thirdly, the powerful influence for good of cultivation of the land to which nightsoil is devoted, not only in preventing deep percolation but in decomposing and mineralizing dangerous impurities.

These considerations are doubtless largely within the range of hypothesis and it is necessary to proceed to the evidence which, if it can scarcely be deemed conclusive, is circumstantially cogent. We see the sudden upward trend of the ground-water definitely associated in every area in India, no matter what other conditions prevail, with the rise in the Enteric curve at an interval which we know to be ordinarily required for the incubation of the infection in the host. This association is, further, marked by contrasts in time and place corresponding to the period and extent of the rainfall and its influence on the ground-water (nature of soil, and sub-soil, depth of spring-level, &c.), as is shown by the course of events in time as we pass up the plain from east to west, and also in other areas which are quite distinct in their physical characters; (compare Egypt, where the rainfall factor is eliminated, also S. Africa, where the incidence of the disease corresponds with the period of rainfall—just as in our Monsoon rise—but at a totally different period of the year owing to its position in relation to the equator.) But beyond these general considerations certain striking facts are not wanting in confirmation. The decade, 1892—1901, was marked in India by three years of excess rainfall, *viz.*, 1892-93-94 and by three years of marked defect (the famine years), 1896, 1899 and 1901, and it is instructive to compare the seasonal incidence of the disease in these two periods in different groups of stations which represent some of the chief distinct local areas.

TABLE XXXVII.

Period of Excess Rainfall, 1892-93-94.

Stations.	Quarterly Actuals and percentages.			
	January to March.	April to June.	July to September (Rains).	October to December.
	1	2	3	4
Gangetic Plain and Punjab ...	68 10·2	242 36·2	187 28·0	171 25·6=100
Central India (Trans-Vindhyan) ...	45 12·5	64 17·7	222 61·5	30 8·3=100
Deccan (Tableland) ...	42 15·0	51 18·2	128 45·7	59 21·1=100
All India	453 10·3	1,590 36·2	1,506 34·3	847 19·3=100

Period of Failure of Rains, 1896, 1899, *and* 1901.

Stations.	Quarterly actuals and percentages.			
	January to March.	April to June.	July to September (Rains).	October to December.
	1	2	3	4
Gangetic Plain and Punjab ..	182 30·0	163 26·8	100 16·4	161 26·2=100
Central India (Trans-Vindhyan) ...	55 12·0	139 31·0	183 41·0	69 16·0=100
Deccan (Tableland) ...	62 21·4	72 25·0	98 34·0	57 20·0=100
All India	702 17·7	1,402 35·4	1,120 28·3	739 18·6=100

Attention is directed to the contrast shown in the incidence on the second and third quarters in the two periods, than which nothing could be more marked. With excess of rainfall the tendency is to greatly increased incidence on the third quarter everywhere; with failure of the rains, while in Central and Southern India the third quarter maintains its pre-eminence as the season of maximum prevalence, there is a distinct approximation to the relative distribution characteristic of the Northern (Continental) area.*

Further, it can be shown so far as observations are available, that the total bacterial content of the well-waters is at its

* It will be shown subsequently (Chapter VII.) that the incidence of Enteric on the *first* quarter, depends in a notable degree on the precipitation of the *previous* monsoon period, but that is beside the point under discussion here.

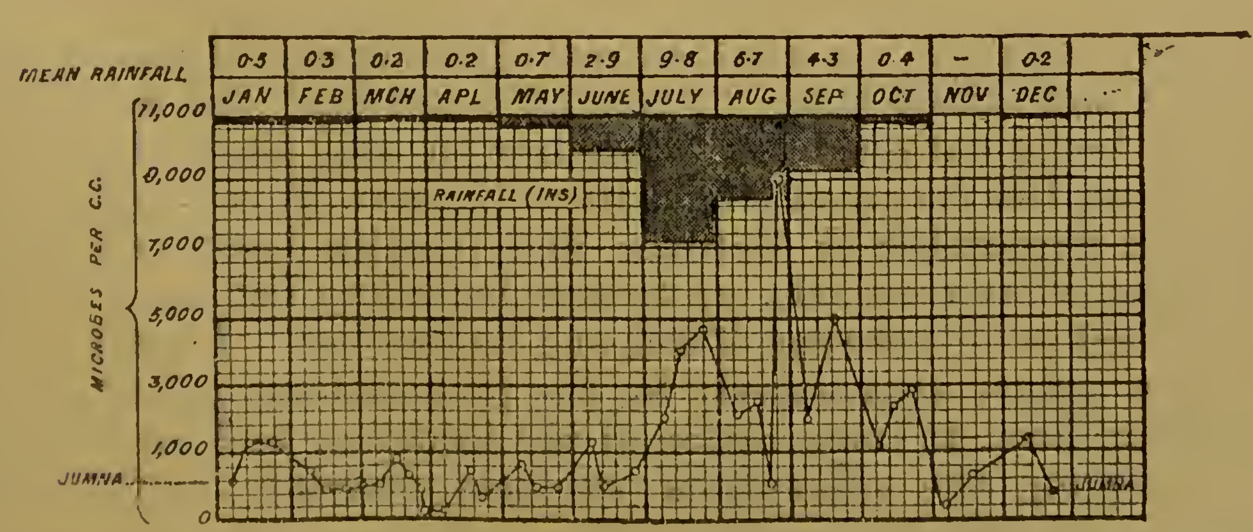
highest point during the period of the rising of the ground-water, the association being so definitely marked as to admit of no question, and of but one interpretation. I have been furnished by Dr. Rao, the Bacteriologist to the Mysore Government, with the following statement, showing the results of his examinations during the years 1903-04. The South-West Monsoon sets in here in June and merges into the North-East (or retreating) current which lasts to the end of November.

	No. of microbes per c.c. 1903.		1904.	
January	1260		1232	
February	1188		995	
March	983		884	
April	880		803	
May	876		941	
June	1051	Monsoon.	1156	Monsoon.
July	1264		1300	
August	1475		1523	
September	1748		1732	
October	1848		1637	
November	1846		1396	
December	1544		1232	

Mr. Hankin, the Bacteriologist of the United Provinces of Agra and Oudh, in a paper presented to the Indian Medical Congress, gives the results of his examinations of the water of the river Jumna as regards the total microbic content per c.c. throughout the year 1894. The following chart is copied from one which he made to illustrate his remarks :

CHART No. XIV.

Number of Microbes per c.c. present each month in the water of the river Jumna (Hankin).



The original chart affords a comparison between the Indian river and the Thames and the Spree, and a glance shows how much purer the first is, from the bacteriological standpoint, than either of the latter. In the case of the Thames, the worst time of the year is in the quarter, November to January (45,000 to 65,000 per c.c., Frankland) ; in that of the Spree, the numbers are highest in April (17,000) and September (16,000). In winter in North Germany the ground is covered with ice, the period of high summer showing the greatest purity both in Europe and India. The water of the Indian rivers at this time is, as a rule, diverted into irrigation canals and owing to the drought, there is no drainage from the land, beyond the domestic waste from communities on the banks. The river levels are at the lowest and the microbes are now most exposed to the disinfecting action of sunlight and to oxidation processes which, at the high temperatures prevailing, are doubtless far more energetic than in Europe. With the rains, much refuse is washed into the rivers from the drainage area, but Mr. Hankin remarks that the increase in the number of microbes is not so great as might be expected as a great part of the water consists of melted snow from the Himalayas. This influence, however, probably operates with greater force at the height of the hot season.

There can be no question of the frequent presence of specifically infected filth upon and in the soil, and it is therefore no extravagant assumption to associate the measure of microbic impurity of the water-supplies with the danger of their specific pollution. Precisely similar curves could be given for other places; see, *e.g.*, *Ind. Medl. Gaz.*, July 1905.

We may still turn to another side for indications of this rôle of the ground-water in association with the increased prevalence of the disease, *viz.*, to localities where no such obvious influence can be predicated or even suggested. In the case of Aden, for example, we have an elevated barren volcanic rock, a rainless and thirsty land "where no water is,'' the drinking-supplies being obtained by condensation and stored in reservoirs above the occupied site. Here Enteric Fever begins to appear in September or October and remains most prevalent during the winter months up to and including February ; it is at its lowest point between March and September. The seasonal incidence points suggestively to the predominant influence of the human host, to importation of the infection and its limited spread among the susceptible subjects arriving during the period of greatest prevalence.

Again, in this connexion we may take account of the course of the disease in the Hill stations which are, as a rule, served by more or less remote mountain springs, the outflow of which is conducted by pipes to the site ; this is assuredly ground-water, but it issues from the rock at great depth and is rarely, if ever under present conditions, subject to pollution *in situ* by way of the surface soil, nor can it influence in any other more occult way the health of the men or the viability of the germ. If we now examine the seasonal incidence on these stations as a group, we find the disease almost at its full measure of prevalence during the first month of their occupation (April or May according to the area) ; there is a slight increase in the following month and thereafter, till and including September, Enteric Fever stands at a fairly fixed level ; the troops return to the plains in October, and the number of cases falls to one-half of the previous monthly average, which is doubtless the proportion it should show for the number of days of that month spent by the men in the hills. It would appear clear that here, again, we have to look chiefly to the human host as the determining factor of the incidence, and to importation for the original source of the infection.

Having now reviewed the physical conditions which accompany and probably determine the seasonal incidence of Enteric Fever in the continental area, we may turn to the consideration of the problem presented in the Trans-Vindhyan uplands and the Deccan tableland (peninsular area), where the disease is also endemic, but where we see the maximum incidence shifted from the second to the third quarter of the year. As we pass southward from the great Indo-Gangetic plain to cross the Vindhyan hill-barrier we find the alluvium giving place to sandstones and other sedimentary rocks towards the East, while the Western portion of the area is covered by a sheet of volcanic rock which is an extension of the great "trap" formation, which furnishes the well-known "black cotton" soil of the Central Provinces and of the Deccan tableland. Here we find an undulating country broken up into highland plateaus and shallow river valleys, the black soil being superposed upon more or less solid rock at a very small depth from the surface and frequently exposed in outcrops.

In the Central Provinces area, a very large proportion of the hilly tracts is covered with forest, while the Deccan proper is characterized by its great undulating plains (elevated to between 1,000 and 2,000 feet) divided up by flat-topped ranges of hills, the sides of which are marked by conspicuous terraces due to the outcrop of the basalt. The vegetation of the trap area is characteristic and quite distinct from that occurring on any other soil. The peculiarity consists in the prevalence of long grass and bush and the paucity of large trees, both bush and trees being deciduous. The result is that from November to March the whole country, save where cultivated, presents a uniform straw-colored surface, whilst from March when the grass is burnt, until the rains commence in June, the black soil and rock give the country a remarkable aspect of desolation which is transformed into verdant beauty during the monsoon period. Still farther South (Mysore plateau) we get into a region of the older crystalline rocks. The scanty rainfall of the greater part of this peninsular area and the influence upon the climate have been alluded to (Chapter III.), the full force of the monsoon being expended upon the western face of the protecting Ghâts. Here again, the winter rains of Northern India due to the cyclonic storms which arise in Persia and traverse Baluchistan to affect the continental area with rain and cold winds, are lacking, as are also the characteristic hot, dry, westerly dust-bearing winds so characteristic of the hot season in the North. Lastly, we have the very peculiar physical properties of the shallow surface soil; this is very absorbent and retentive of moisture, and it is constantly likened to a saturated sponge, the consequences being that surface drying and drainage are equally defective. In the hot weather it contracts and cracks into large fissures and holes which even render riding over the country hazardous.

No geological and geognostic conditions could offer a greater contrast to those prevailing in the Indo-Gangetic plain, which have been fully described, but inasmuch as one of the most puzzling of the epidemiological problems is involved in the contrast in the periods of the respective maxima of incidence, it is desirable to have a clear conception of the facts. The great plain of the "continental" area is a flat expanse composed of alluvial sheets of sands, marl and clays of varying and unknown depth, deposited by the great rivers in their course to the sea from their sources in the Himalayas. The Southern part of the plain (the "transition area") is under the influence of affluents from the Vindhyas. In the narrow low "Khadar" lands of the river valleys (highly cultivated but sparsely populated) the water lies near the surface and oscillates with the rise and fall of the river. In the higher "Bhangar" land (older alluvium, intervening between the rivers) on which the cantonments are situated, the ground-water lies at a greater depth (20 to 50 feet) and its level varies to a far less extent, and only indirectly under the influence of heavy (monsoon) rainfall; it lies in beds of sand overlaid and underlaid by more or less impermeable sheets of clay and "Kunkar" (lime and clay). The influence of this clay and Kunkar on organic matters committed to the soil, and on the ground-water has been alluded to and must be borne in mind. Now in the "peninsular" area (Deccan and Central Provinces) we have the broken, undulating semi-highland country just described; the river valleys are very shallow and are cut in narrow gorge-like courses in the basis of igneous rock ("Trap") which, where it is not exposed in outcrops, is always near the surface and is barely covered by the thin layer of the products of its decomposition, the "black cotton" soil, the peculiar properties of which have been described. Below it lies the decomposing trap, in the interstices of which down to the compact basalt, the ground-water is retained to rise rapidly to the surface under the influence of the rainfall. Towards the end of the hot weather, the free water has practically all evaporated, leaving only the moisture which is inherent in the soil particles, and it is stated officially (Statistical Atlas) "that this black soil requires no other form of moisture." The ground-water is not protected by any impermeable sheet of clay as in the northern (alluvial) area, but it is fed directly from the rainfall *on* the surface and, consequently, by the percolation from above and by the rapid rise of the ground-water from below, all surface impurities are quickly dissolved by or suspended in the water-sources. Precisely similar conditions prevail in other parts of the area not covered by trap; the ground-water lies in a shallow subsoil overlying rock, more or less porous, into which the rainfall soaks, and there is an enormous fluctuation in the level during the monsoon and dry periods of the year, *viz.*, from near the surface to a depth of 30 or even 50 feet or more, so that, in the hot weather, the native population relies very largely on surface tanks (ponds) in which the rainfall has been collected. The results of the depuration of the soil by rainfall and rise of ground-water to the surface are seen in the salinity (NaCl) of the well-waters on or near any inhabited site, which is a special feature of this area; the sewage-polluted sites of the older villages provide the chief sources of saltpetre, owing to the vigorous nitrification processes set up.

The reader may be left to form his own conclusions as to the effect of these contrasts on the seasonal incidence of the disease in the two main divisions of the endemic area, when due regard is also paid to the meteorological facts as presented in Chapter III. The three small charts, which exhibit the quarterly incidence of the rainfall and of Enteric Fever (both in actuals) for a period of 12 years, will render clearer the sequence of events in three areas, *viz.*, the true "continental" plains, the "transition" and the "peninsular" areas, respectively.

RAINFALL AND ENTERIC FEVER BY QUARTERS (12 YEARS).

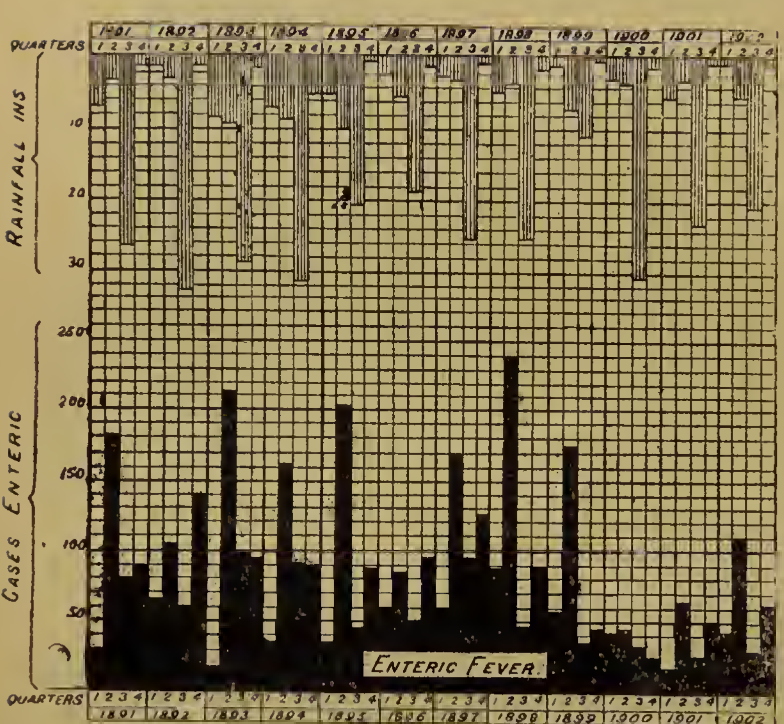


Chart No. XV—Group VI. Northern (Continental) Area.

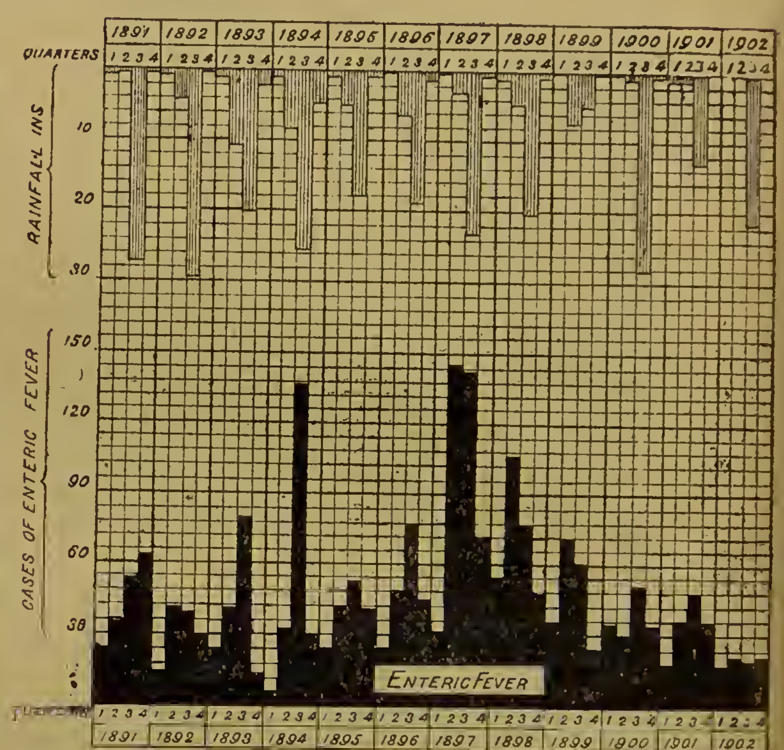


Chart No. XVI—Group VIII. Transition Area.

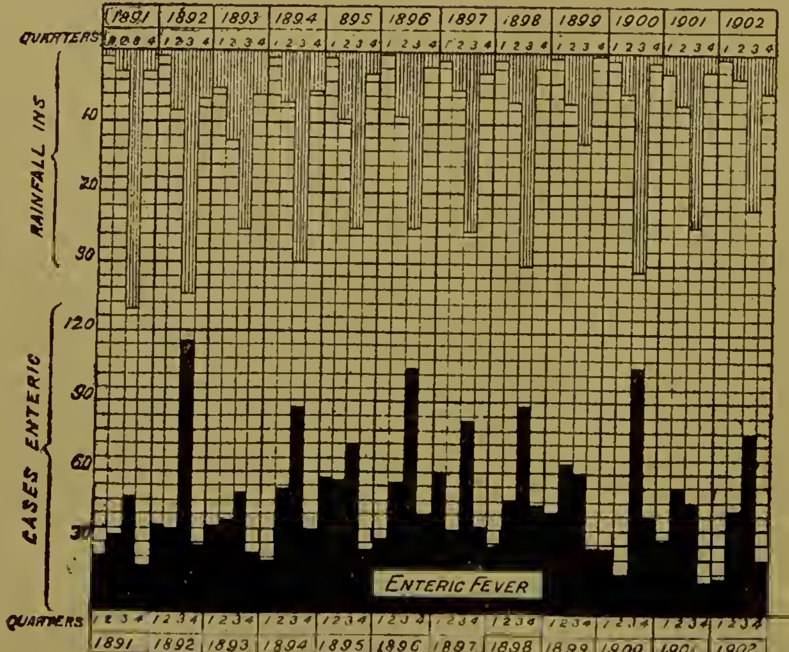


Chart No. XVII—Group IX. (Deccan) Peninsular Area.

Within the whole endemic area, continental and peninsular, we see certain striking characteristics of seasonal incidence common to both, depending on the operation of the salient physical factors which prevail in a certain measure all over the area; but there are also characteristic modifications and contrasts of a more or less secondary order stamped upon the seasonal *facies* of the epidemiology under the influence of certain well-marked differences in the configuration of the country; and notably, in the nature of the soil, the subsoil and the water-supplies, which in association with the other meteorological factors influence the dissemination of the disease and so alter the proportional incidence on the two middle quarters of the year. The more sharply-defined characters of the seasons in the northern section of the endemic area are associated with a corresponding seasonal *facies*, while in the southern section the physical factors co-operate to enhance the incidence on the third quarter in comparison with that on the second (the incidence of dysentery and diarrhœa conforms). After all, the difference is one of degree only, and that it is chiefly due to the varying operation of the physical factors (environment), whether affecting the host, the germ, or the means of access of the latter to the former, or, as is probable, all three, is indicated by the course of events described in the continental area. The phenomena of the seasonal deferment of the incidence in correspondence with well-defined natural processes, and the results observed in the intermediate area (Group VIII.) afford strong testimony in favour of this conclusion, which is supported by the experience of a similar sequence of events in corresponding latitudes (below the equator) in South Africa, where the physical conformation of the country is in many respects similar. We have also to take account of instances where more striking aberrations occur, which can only be ascribed to marked departures in the character of the environment, and in the course of the climatic influences. In the present connexion, it need only be added to what has been said in this and the previous chapter, that some facts which tend to elucidate the question will be found in the details given for representative stations in the different geographical groups in Appendix II. The chart which exhibits the course of events in the Deccan group (IX.) should also be consulted.

Where, perhaps, in certain local instances we appear to discover a departure from the ruling association of physical conditions and disease prevalence, a closer examination will generally solve the difficulty. Take the case of Quetta, for example here we have one of the largest cantonments which, in virtue of the physical nature of its site, surroundings and climate, must be associated with the continental area. It stands in a valley at an elevation of 5,500 feet, among the bleak, bare Baluchistan highlands, on a loamy, alluvial soil, subject to great heat in the hot weather months and in those which elsewhere are associated with the rains, *i.e.*, from May to September, and with a daily range of temperature which is unrivalled elsewhere. In brief, in all the most essential respects it takes its place within the true continental area, as its situation on the map alone would indicate. And yet the seasonal incidence of the disease is in direct contrast with that of the continental area; thus for the period 1890-1903 we find quarterly percentage incidence as follows :—

January to March.	April to June.	July to September.	October to December.
2·9	10·1	52·2	34·9

which, taken alone, would associate it indubitably with the peninsular area. The water-supply is from a river rising in the barren and uninhabited hills, the intake being several miles from the cantonment, and little or no question arises of the direct influence of the ground-water on the water-supply. But if we look to the meteorology we find very suggestive indications of the reasons for its aberration as regards the seasonal incidence of the disease. Briefly, the climatic phenomena are to all intents and purposes reversed ; the rains, including much snow, occur during the first four months of the year (January to April)—precipitation occurring, on the average, on one day in four ; intense cold, accompanying frequent cyclonic storms, is experienced during the winter, excluding all chance of vegetation and winged insect life, which only become possible with the aid of irrigation when the summer warmth is established. In many respects the locality approximates in its climatic characters to northern continental Europe, but with these characters exaggerated under the influence of altitude and latitude, and we see the results in the course of the Enteric Fever curve. Occasionally a few sporadic cases in March, April and May are followed by a marked rise in June, the acme point being reached in September ; the disease curve is maintained at a high level from

July to November, but is nevertheless subject to remarkable fluctuations from year to year. Now the June-September period in Quetta corresponds very closely in all essentials, temperature, winds, drought, &c., with that of April-May in the northern continental area, and we cannot but expect similar results, given the infection and the susceptible material which are abundantly present. When we come to deal more directly with a review of the chief sources of infection we shall see a further parallel in the probable rôle of dust in its influence on the dissemination of the disease ; it is merely necessary to note here, in connexion with the foregoing account of the conditions, that a report has been received from the Medical Officer, in charge of the Station Hospital, that it is precisely during the period of June to September that both dust-storms and flies are most prevalent. For other instances, the reader may recall the remarks made on Aden and the Hill stations on a previous page.

Having dealt with the influence of the environment, we may sum up, briefly, the considerations that point to the human host as a controlling factor in determining seasonal incidence. This influence is in the first place obvious as at once the prime and chief source of infection and as providing the essential stage for the disease process. If the source of infection be wanting, or if, on the other hand, there be an absence of susceptible subjects, no local, no physical conditions of the environment will avail to produce the disease ; these only operate in the presence of the infection and of susceptible subjects ; (compare the Hill stations in winter and summer respectively). Moreover the host is the effective agent for the importation of infection, and the incidence in time will necessarily be determined by the presence or absence of infected and susceptible individuals ; by their age, and by their length of service involving or precluding previous experience of the disease in India or elsewhere ; by the period of their arrival in a locality, by movements, extent of aggregation, and, further, by special conditions which favour in a peculiar degree the multiplication of foci of infection and its dissemination, *e.g.*, life in camps, during manœuvres, campaigns, &c. All these conditions will have a specially marked influence on the course of the disease in time and place, under the conditions to which the army in India is subject, from the fact that it is an immigrant and floating community, in constant movement at fairly well-defined seasons of the year and subject to constant reinforcement by fresh susceptible bodies. This is altogether a different order of things from that presented by a more or less stable civil community under fixed conditions, which in the constant presence of infection will develop a corporate resistance or immunity to the disease, save at special times of danger, as in the sudden pollution of the common water-supply. On the other hand, we may not overlook the probable influence of physical conditions as operating upon the host and upon the germ to induce effective infection, where under other circumstances (as in the normal environment of the host) this would not occur ; we may well conceive this as happening if we assume that the virus, in a more or less attenuated form, is far more prevalent as a parasite (actual or potential) than the overt clinical and pathological evidence would appear to warrant.

The facts reviewed exhibit a rise in the prevalence of the disease commencing in the autumn with the arrival of fresh drafts and reliefs in the country and with the return of the men from the Hill stations, where we know the infection is usually abundant ; on the other hand, we see the seasonal incidence of the disease in the Hill stations determined almost solely by the presence of susceptible subjects, some of whom have imported the infection,—an example also of the effect of traffic. Again, convalescents returning from the hills to their corps in the plains, on the setting in of the monsoon in July, may provide sources of infection for the rising prevalence at that time. We have also seen how the actual numbers of men, as drafts, arriving at a place determines largely the local incidence by multiplying the risks of importation, and the sources and subjects of infection, and physical conditions of the environment must operate on these factors to enhance or modify the prevalence of the disease. The smaller remoter stations, with fewer accessions of susceptible *personnel* at longer intervals, approximate more closely to a stable civil community in all their conditions and, as a consequence, we see a far less defined seasonal *facies* in disease incidence. An opportunity of witnessing the effect of age and previous experience of the disease on the seasonal incidence is afforded by the circumstances attending the suspension of reliefs and drafts during the Boer war. This is exhibited in two main directions ; the rises in the curve to the maxima are notably less steep and they are distinctly deferred. (See next page.)

On the whole, there is a decided tendency to the shifting of the incidence from the hottest season of the year (May to August inclusive), to the autumn and winter months, during

TABLE XXXVIII.

Influence of Altered Age and Service Constitution on Seasonal Incidence.

Actuals and percentages by Months.

Commands.		Jan., Feb., March.			April, May, June.			July, Augt., Sept.			Oct., Nov., Dec.		
Bengal	1890-96 ...	218	160	330	506	518	282	266	396	357	281	315	468
			17·3			31·9			24·9			26·0	
	1900-01 ...	56	17	31	74	60	33	28	31	34	33	43	55
			21·0			33·7			18·8			26·5	
Punjab	1890-96 ...	64	43	89	337	690	612	521	398	348	187	159	170
			5·4			45·3			35·0			14·3	
	1900-01 ...	31	12	15	82	88	72	45	31	27	17	19	24
			12·5			52·3			22·2			13·0	
Madras	1890-96 ...	51	45	77	69	83	96	160	196	125	83	49	84
			15·5			22·2			43·0			19·3	
	1900-01 ...	6	8	16	11	16	12	28	28	31	15	9	3
			16·4			21·3			47·5			14·8	
Bombay	1890-96 ...	57	86	132	179	132	117	267	306	259	153	79	80
			14·9			23·1			45·0			16·9	
	1900-01 ...	35	26	34	42	29	24	26	85	135	74	67	28
			15·7			15·7			40·7			27·9	
INDIA	1890-96 ..	390	334	628	1091	1423	1107	1214	1296	1089	704	602	802
			12·7			33·9			33·7			19·7	
	1900-01 .	128	63	96	209	193	141	127	175	227	139	138	110
			16·4			31·1			30·3			22·2	

(*Note.*—The period 1890-96 is taken to avoid the disturbing influence of the campaign in 1897-98—see later.)

1900-01 when both the numbers and the proportion of susceptible men were at a minimum; this is best shown by reducing the actuals to monthly percentages of the monthly standard in the two periods, respectively. The total for each period is multiplied by 365 and divided by 31 to give the standard for a month of 31 days, and the actuals for the months are, where necessary, corrected for variations in length, and then all are reduced to percentages of the standard.

	Jan.	Feb.	Mar.	April	May	June	July	Augt.	Sept.	Oct.	Nov.	Dec.
INDIA 1890—96	43	41	69	124	157	126	134	143	124	78	68	88
INDIA 1900—01	86	47	65	146	130	98	86	118	158	94	97	74
Difference (+or−)	+43	+6	−4	+22	−27	−28	−48	−25	+34	+16	+29	−14

This exhibits an approximation to the classical form assumed by the seasonal incidence in Europe, but the distinctive features of the course of the disease in India are, of course, still very evident, in the double rise, summer and autumnal, and it is only in the relative proportional distribution that we find a very decided modification under the influence of the altered age and Indian service constitution of the forces. The diminished incidence on the hotter and more trying months is probably to be attributed to the better physiological adjustment of older men who have had, as a body, longer experience of the environment, though its effects are still most potent and obvious.

The following statement gives the ratios per mille of strength for Enteric Fever yielded by men under 25 years of age and under 2 years' of Indian service respectively, in the different months of 1903:—

India, all Plains Stations.	Jan.	Feb.	Mar.	April	May	June	July	Augt.	Sept.	Oct.	Nov.	Dec.
Age, up to 25 years	1·8	1·0	4·2	3·8	3·9	3·4	1·5	1·9	3·5	2·4	2·2	2·8
Service, up to 2 years	2·2	1·07	5·3	4·7	5·0	4·1	2·0	2·3	4·0	2·6	2·4	3·1

Of course many of the men included in the one category appear also in the other, but this shows the excessive susceptibility of those who are new to the environment, and this especially at the most trying periods of the year.

Again, with regard to the influence of conditions which are specially favourable to the multiplication and dissemination of infection, we may take the Frontier Campaign of 1897-98, and we shall see that, apart from the Enteric Fever recorded in the field itself, the effects are demonstrable in the altered monthly incidence of the areas in India from which the troops were mostly drawn and to which they returned at different periods during the course, or at the conclusion, of the operations. These extended from July 1897 to March 1898 and, consequently, if they exercised any influence, it should be exhibited in a shifting of the relative proportional incidence towards the later part of the former year and the earlier part of the latter year; and this, indeed, is what occurred, thus:—

TABLE XXXIX.

Campaign Influence on Seasonal Incidence.

Actuals and percentages by Periods.

Groups.	Jan., Feb., Mar., April.	May, June, July, Augt., Sept., Oct.	Nov., Dec.
Nos. V., VI. & VII. (Punjab & Gangetic plain), 1890-96	223 138 294 511	785 439 314 384 311 296	368 520
	25·4%	55·3%	19·3%
Ditto 1897-98	161 93 141 218	293 138 54 99 74 57	169 201
	36·1%	42%	21·8%

If we divide the annual aggregates, in each case, into two six-monthly periods, *viz.*, November to April and May to October, respectively, we find that in the same combined groups the relative incidence was entirely reversed. In what may be deemed the normal series of years (1890-96), the percentage incidence on the period, November-April, was 44, and on May-October it was 56, whereas in 1897-98, the campaign years, the percentages were 58 and 42, respectively. This striking contrast would be even greater, if the cases occurring in the early months of 1897 and in the later months of 1898 be eliminated, as occurring before and after the period of active service. It is interesting to note that precisely the same phenomenon is exhibited in these groups as regards the incidence of dysentery in 1897-98, the whole normal seasonal course of the disease being altered, the maximum prevalence being shifted to the winter months during which active operations were in progress. In both cases this can only be ascribed to importation of the infection by men returning from the field, sick or convalescent, or not recognized as suffering from either disease, and beyond this, to its dissemination among the troops in cantonments.

The reader is referred to the attached appendices and to the Summary of the Epidemiology (Chapter VII.) for some additional material facts in regard to the influence of meteorological and telluric phenomena; the conclusions on the whole body of evidence are there summarized and an attempt is made to combine and focus them in a true perspective.

APPENDIX I. TO CHAPTER IV.

ENTERIC FEVER.—Incidence on 100 Chief Stations occupied by British Troops, 1891-1900 and 1901-1904. Arranged in order of mean ratios 1891-1900. Ratios of Admissions per mille.

N. B.—The Roman figure against each Station represents the "Geographical Group" to which it belongs.

Stations.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1891 to 1900.	1901.	1902.	1903.	1904.
1 Benares (V)	20·7	46·4	23·7	54·2	101·7	123·6	122·4	15·6	10·7	23·6	**54·7**	...	9·8	10·4	13·8
2 Agra (VIII)	19·6	15·5	42·6	37·6	31·1	44·3	166·4	73·5	27·2	15·7	**46·3**	21·4	3·9	19·9	25·2
3 Lucknow (V)	58·8	29·6	27·2	25·5	56·2	22·8	48·5	74·1	32·6	30·9	**40·0**	16·6	28·5	37·7	51·6
4 Ahmednagar (IX)	30·9	25·3	18·7	62·2	15·2	16·9	53·0	53·7	66·0	37·0	**38·2**	45·1	21·0	6·6	2·0
5 Nasirabad (VIII)	54·3	18·6	21·0	19·8	23·8	37·9	35·8	41·9	50·1	71·7	**37·4**	48·5	48·6	121·8	21·8
6 Allahabad (V)	21·5	24·8	20·4	29·1	32·1	93·5	44·8	47·6	30·6	20·8	**37·0**	13·6	13·7	11·3	5·5
7 Jhansi (VIII)	18·8	59·6	41·0	9·4	35·3	29·7	81·9	40·4	37·9	17·1	**36·6**	11·8	13·4	38·7	50·1
8 Meerut (VI)	34·4	23·0	36·6	41·0	44·5	33·4	47·4	40·0	24·6	12·7	**34·8**	13·3	31·2	50·4	44·9
9 Shahjahanpur (VI)	13·3	83·0	64·8	45·6	30·1	2·2	4·7	64·7	6·0	...	**34·0**	11·8	21·0	15·0	1·8
10 Umballa (VI)	15·9	21·9	35·8	35·6	40·9	24·2	64·1	35·3	32·0	14·3	**33·1**	19·6	43·2	49·4	40·7
11 Jubbulpur (IX)	18·5	47·0	39·7	24·4	20·4	33·1	31·6	86·8	31·1	11·7	**32·1**	31·3	37·1	42·1	23·0
12 Peshawar (VII)	19·4	11·0	14·7	27·7	49·2	45·4	44·2	52·0	25·3	19·5	**31·7**	18·7	13·8	33·8	12·7
13 Mhow (VIII)	20·0	13·9	6·3	67·0	17·8	39·3	49·0	45·6	29·3	20·3	**30·9**	37·3	34·8	48·0	27·0
14 Kirkee (IX)	16·8	29·0	21·9	20·6	29·4	54·7	20·5	37·4	43·0	23·6	**29·5**	25·2	70·2	6·6	39·2
15 Rawalpindi (VI)	50·3	26·8	31·5	12·8	21·2	12·9	32·2	51·8	38·4	21·6	**29·2**	10·3	18·5	23·0	29·2
16 Campbellpore (VI)	14·4	28·9	73·9	18·4	18·5	15·1	89·0	14·2	11·8	11·7	**29·1**	...	7·6	4·4	...
17 Muttra (VIII)	48·7	2·0	48·8	21·5	5·3	10·9	29·6	94·3	44·0	13·0	**29·0**	...	34·5	3·8	14·0
18 Barrackpore (IV)	...	14·6	24·7	12·1	3·0	69·8	69·3	38·9	18·2	13·1	**28·1**	6·4	17·5	22·2	25·4
19 Fort Lahore (VI)	13·3	...	9·5	10·3	21·5	53·2	58·8	87·0	22·0	...	**27·4**	18·7	34·8	8·9	20·8
20 Bareilly (VI)	49·6	44·4	21·7	29·2	35·7	32·6	14·7	20·9	15·5	5·3	**27·2**	38·7	23·6	8·8	10·9
21 Nowshera (VII)	20·6	12·6	26·7	58·2	23·6	28·0	23·9	47·1	5·4	21·2	**25·7**	5·5	3·8	12·3	10·0
22 Meean Meer (VI)	12·7	14·7	4·4	69·9	16·8	39·0	16·9	47·2	19·9	16·9	**25·4**	13·6	15·0	19·0	14·8
23 Ahmedabad (VIII)	25·6	28·6	56·0	33·9	64·4	4·3	8·3	4·3	4·5	4·9	**24·4**	4·5	...	...	8·4
24 Fyzabad (V)	23·1	14·2	26·4	22·3	20·1	38·9	11·6	47·5	8·4	7·5	**23·3**	9·5	29·1	20·2	13·8
25 Secunderabad (IX)	12·2	22·4	15·7	20·8	28·2	32·6	36·2	17·4	16·8	30·3	**23·2**	16·0	8·8	10·4	23·2
26 Deesa (VIII)	9·9	17·4	24·2	10·8	27·7	6·6	44·2	33·4	34·1	16·2	**22·8**	7·2	12·9	18·7	14·4
27 Bangalore (XI)	24·8	17·0	17·4	18·4	8·4	24·1	40·2	30·3	36·6	7·3	**22·7**	6·0	12·0	18·7	31·7

28 Sialkot (VI)	35·4	52·4	49·3	19·0	·8	11·6	15·5	17·7	14·4	...	**22·6**	2·9	27·5	32·6	29·6
29 Amritsar (VI)	33·3	14·7	11·7	13·5	30·6	17·9	60·5	19·1	10·0	5·2	**21·5**	5·2	4·2	16·6	5·7
30 Jullundur (VI)	26·9	6.2	49·3	7·1	5·5	11·4	20·7	48·3	22·6	4·6	**20·8**	1·9	3·9	...	34·7
31 Cawnpore (V)	23·0	26·2	11·5	25·5	19·2	23·1	17·2	25·2	16·7	13·4	**20·3**	15·6	18·7	21·3	9·2
32 Fort Allahabad (V)	29·7	...	4·9	13·4	14·6	56·3	44·8	25·1	5·3	...	**20·0**	12·0	10·3	5·4	...
33 Calicut (X)	...	9·9	29·1	20·0	9·3	49·5	49·0	...	...	34·1	**20·0**	...	...	10·9	11·0
34 Poona (IX)	19·2	31·0	11·8	15·7	22·7	16·9	18·1	24·2	9·0	19·7	**18·9**	8·6	18·6	31·4	33·8
35 Neemuch (VIII)	41·8	7·7	22·0	2·3	8·5	15·3	21·9	10·2	27·6	33·7	**18·7**	24·5	8·4	41·0	20·3
36 Sitapur (V)	15·5	34·1	38·7	16·8	27·8	12·0	12·3	11·3	8·2	...	**17·0**	..	8·7	6·3	4·4
37 Cannanore (X)	9·8	...	...	...	8·8	135·4	11·6	..	...	...	**16·3**	...	13·5	...	...
38 Madras (XI)	22·0	22·9	52·2	15·3	11·3	3·6	9·2	5·3	1·7	7·8	**16·3**	1·7	15·0	11·5	6·9
39 Delhi (VI)	9·5	6·6	12·6	25·9	15·6	3·5	10·2	10·0	30·2	28·8	**15·5**	9·5	3·5	23·5	7·2
40 Deolali Depôt	5·1	11·0	10·3	11·6	17·2	30·2	17·3	7·2	25·1	9·9	**14·7**	10·1	12·8	17·0	8·7
41 Mooltan (VII)	10·3	29·9	7·5	15·3	29·4	7·6	1·9	13·5	17·0	23·1	**14·5**	17·5	21·8	2·4	...
42 Ferozepore (VI)	9·0	13·5	13·3	17·2	9·3	6·5	12·1	33·7	25·0	7·8	**14·4**	22·1	4·5	4·6	10·8
43 Mallapuram (X)	...	6·7	6·5	13·8	13·6	47·3	32·3	6·8	6·8	6·9	**14·1**	...	...	7·1	6·9
44 Pallavaram (XI)	...	...	23·3	..	30·8	32·8	15·6	...	25·0	...	**13·6**	...	...	*	...
45 Roorkee (VI)	39·8	20·3	20·2	15·4	23·2	7·5	2·6	8·5	...	...	**13·5**	4·9	20·6	21·2	17·7
46 Fatehgarh (V)	9·1	9·0	...	13·5	19·2	46·5	25·5	...	5·0	...	**12·8**	4·7	12·3	...	72·5
47 Kamptee (IX)	6·8	12·6	9·9	15·5	17·2	11·1	11·5	21·0	11·4	12·5	**12·8**	11·9	2·8	28·2	8·7
48 Nowgong (VIII)	19·3	8·9	24·9	10·8	2·7	3·2	2·4	18·1	16·9	20·1	**12·7**	3·6	9·9	35·0	9·3
49 Dum Dum (IV)	18·8	6·2	14·5	9·2	19·7	10·2	1·2	20·6	10·3	11·4	**12·3**	22·5	19·7	...	...
50 Dinapore (V)	5·1	9·4	21·4	9·0	15·7	7·4	8·9	13·8	21·0	12·4	**11·9**	3·2	5·3	49·7	41·7
51 Attock (VI)	8·3	...	...	6·2	18·8	...	32·3	18·4	11·6	12·2	**11·4**	...	23·4	8·9	13·5
52 Saugor (IX)	...	13·8	14·1	11·0	34·5	5·6	7·2	...	2·8	3·3	**9·9**	17·4	...	4·4	7·5
53 Rangoon (I)	2·1	4·4	13·9	3·0	10·0	13·7	22·6	8·3	5·6	9·9	**9·5**	...	4·4	10·8	8·3
54 Indore (VIII)	8·6	9·1	...	...	9·9	40·8	11·2	...	...	7·8	**8·4**	8·3	8·7	52·6	22·9
55 Kurrachee (VII)	4·6	23·7	5·5	4·9	4·9	8·1	8·2	6·8	7·1	1·9	**7·4**	4·0	4·6	2·6	2·5
56 Bellary (XI)	6·5	5·4	...	...	14·4	4·5	13·7	8·3	6·3	4·0	**6·5**	5·2	9·5	19·6	15·9
57 Shwebo (II)	17·6	...	...	...	..	19·1	2·2	16·4	3·3	...	**5·9**	...	...	4·1	3·6
58 Sitabaldi (IX)	...	...	...	22·7	22·7	19·6	...	...	...	...	**5·6**	...	...	...	...
59 Fort William (Calcutta) (IV) ...	8·2	2·7	3·5	5·4	6·8	9·5	...	13·3	3·6	1·8	**5·5**	...	3·0	2·3	2·9
60 St. Thomas' Mt. (Madras) (XI)	7·0	3·4	...	6·1	8·9	9·3	12·6	6·5	...	...	**5·4**	3·5	2·8	...	14·0
61 Hyderabad (VII)	...	15·8	...	3·2	3·3	15·7	2·7	4·0	6·1	...	**5·2**	2·6	4·4	2·1	12·1
62 Satara (IX)	...	...	5·7	9·3	9·1	4·2	...	11·6	...	11·4	**5·2**	28·6	...	10·0	...

APPENDIX I. TO CHAPTER IV.—(*Continued.*)

Stations.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1891 to 1900.	1901.	1902.	1903.	1904.
63 Meiktila (II)	...	21·5	5·1	8·9	7·9	...	...	...	7·5	...	**5 0**	6·3	10·6	7·4	2·6
64 Aden (Sea-port) ...	1·2	3·3	6·6	5·7	4·8	3·9	...	10·8	6·4	5·4	**4·9**	13·9	7 5	5·4	7·3
65 Fort Dufferin (Mandalay) (II)	11·1	3·9	7·0	8·0	3·9	2·9	2·0	4·4	1·0	2·8	**4·7**	5·7	4·9	7·5	1·6
66 Colaba (Bombay) (X)	2 1	4·9	8·7	2·2	9·2	1·7	3·5	2·5	7·9	3·4	**4·6**	·8	5 3	1·5	2·3
67 Bhamo (II)	...	8·2	3·7	3·8	13·0	...	...	3·3	6·6	4·6	**4·2**	...	†	16·7	...
68 Belgam (IX)	...	1·8	2·0	1·7	4·0	6·9	4·5	1·9	7·1	9 0	**3·9**	6·4	7·5	3·6	12·8
69 Thayetmyo (II)	5·9	8·8	3 0	3·6	5·5	...	...	...	6·7	5·1	**3·7**	6·5	4·3	6·6	3·6
70 Poonamallee Depôt	18·3	...	...	...	...	.	5 6	...	6·5	...	**2·9**	..	...	7·	...
71 Port Blair (I)	...	...	...	...	...	7·0	7·1	...	7·1	...	**2·1**	...	...	...	...
72 Fort Chingri Khal (IV)	*	*	*	...	...	.	31·2	...	14·7	...	...	...	...	...	...
73 Fort Fulta (IV)	*	*	*	...	...	...	...	...	...	...	...	...	...	...	...

* Included in Fort William.

Combined ratio of Plains Stations (1891-1900) 22·3 *per mille.*

HILL STATIONS

Stations.		1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1891 to 1900.	1901.	1902.	1903.	1904.
74 Subathu	XII	15·8	98·1	28·7	81·5	63·3	243·3	77·6	22 5	42·9	35 6	**69·0**	29·8	12·0	5·9	12·0
75 Cherat	XII	110·0	11·5	75·9	70·5	19·7	28·7	208·9	82 1	21·1	13·8	**61·9**	16·8	21·1	27·2	15·5
76 Taragarh	XII	50·0	17·6	31·2	48·8	179·5	...	...	23·3	63·8	85·1	**58·7**	62 5	142·9	45·1	23·8
77 Dagshai	XII	13·5	119·0	63·1	81·7	27·7	52·2	136·2	26·3	29·1	10·7	**58·4**	20·3	...	20·4	7·2
78 Chakrata	XII	20·2	45·3	14·1	13·0	52·0	8·8	72·1	75·6	64·4	11·5	**36·8**	8·7	8·3	4·1	6·7
79 Jutogh	XII	25·8	35·7	9·1	17·2	69·9	42·6	63·1	24·7	32·1	21·0	**34·2**	..	16·5	16·5	8·4
80 Quetta	XII	9·7	30·7	8·1	17·1	11·9	60·5	22·5	108·5	10·8	50·7	**33·0**	12·3	33·0	17·5	28·2
81 Baragully	XII	*	...	21·7	133·3	95 2	...	40·0	17·9	20·0	...	**31·7**	19·6	...	·7	...
82 Ranikhet	XII	18 6	21·1	27·6	24·7	11·8	72·1	23·5	68·3	29·1	12·6	**30·9**	19 3	26·3	27·3	19·1
83 Solon	XII	17·2	18·4	59·1	48·9	42 0	14·4	71·9	...	28·6	7·1	**29 7**	...	...	14·0	8 9

† No troops.

84	Kalabagh	XII	45·5	25·6	42·5	...	39·2	...	...	...	127·7	...	**27·7**	...	...	...	17·9
85	Dalhousie		23·8	23·7	22·2	36·4	19 2	19·3	16·7	41·2	33·0	17·3	**24·9**	10·6	22·5	1·1	24 4
86	Naini Tal		51·9	31·9	15·1	20·4	53·6	7·4	32·5	18·5	24·2	...	**24·7**	...	...	7·0	14·4
87	Pachmarhi		17·5	151·8	...	9·2	17·5	8·8	12·0	8·5	...	...	**22·7**	8·4	16·1	31·3	148·1
88	Murree		28·7	22·9	42·0	...	15·2	...	22·7	45·5	26 7	10·4	**22·3**	8·4	21·7	7 8	8·5
89	Camp Gharial		70·0	12·7	5·5	9·3	37·2	6·7	27·9	28·1	6 4	29·6	**21·5**	9·2	13·1	3·6	6·1
90	Camp Lower Topa		18·3	10·8	74·4	8.3	...	15·4	17·2	40·0	...	16·9	**21·1**	...	50·5	9 4	29·4
91	Kasauli		11 7	30·8	10·6	16·5	13·3	16·0	29·1	29·5	38·7	15·7	**21·0**	28·2	18·0	36·3	15·7
92	Mount Abu		...	29·0	38·1	18·9	20·0		..	11·0	11·0	21·1	**15·8**	11·4	15·4	49·6	...
93	Camp Thobba		22·5	...	17·7	3·4	...	6·4	5·1	32·8	28·8	11·4	**13·7**	7·8	4·1	2·2	33·8
94	Chaubuttia		3·1	11·2	23·4	7 0	51·4	3·0	3·7	12·8	12·2	7·1	**13·6**	3·3	25·5	10 5	9·6
95	Khyragully		16·4	17·9	...	...	...	14·9	30 3	25·0	33·3	...	**12·9**	16·7	...	20·8	...
96	Landour		18·4	...	6·3	13·1	...	...	32·5	31·8	18·0	4·8	**11·8**	4·9	5·2	10·9	16·2
97	Purandhur		27·3	7·9	22·5	7·6	18·2	8·5	...	...	18·5	..	**11·4**	7·0	24·8	7·2	5·8
98	Kuldunnah		...	27·8	5·9	6·6	16 9	4 1	...	14·4	24·8	2·2	**10·2**	10·4	...	5·9	8·3
99	Wellington		...	10·5	·8	4·5	19·4	11·4	11·7	12·4	13·9	3·6	**9·1**	6·7	22·3	9·2	24·0
100	Darjeeling		2·8	2·6	...	5·4	12·0	...	8·1	5·0	6·4	3·0	**4·5**	3·2	9 3	8·1	5·0

Combined ratio of Hill Stations (1891-1900) 29·2 *per mille.*

APPENDIX II. TO CHAPTER IV.

Synopsis of Reports kindly furnished by Medical Officers, commanding Station Hospitals in India in 1904, as regards the local experience of Flies, Dust and Winds, and the methods and sources of Water-supply and the disposal of Excreta.

(Details as to Water-supply also obtained from Statement issued from office of Q.-M.-G. in India, February 1904.)

Stations and Geographical Groups. (See also Charts.)	FLIES. In what months are flies most abundant as a rule?	DUST AND WINDS. In what months is the Cantonment subject to wind-borne dust?	WATER-SUPPLIES. Means of Raising and Distribution. Distribution { Pipes to Taps = **P.** Iron Buckets = **B.** Water unfiltered = **U.** Municipal piped supply = **M. S.**	DISPOSAL OF EXCRETA. System. Filth Carts to Trenches = F. C. T. Soil cultivated = S. C.
GROUP V.				
1 Benares ...	March, April, September and October.	Strong, middle of April to end of May.	M. S. Ganges water filtered; pipes to stand-posts. **P.**	"Dry earth." F. C. T., S. C.
2 Fyzabad ...	April, May and June.	May and June ...	Wells, total 33 in use; 18 for drinking. Three have pumps and are covered, others with leather buckets and ropes. **U. B.**	"Dry." F. C. T., S. C.
3 Sitapur ...	May and June	*Nil.*	Wells, 5 in use; 2 exclusively for drinking, one only has a pump. **U. B.**	"Dry." F. C. T., S. C
4 Cawnpore ...	September ...	March, April, May and June, before monsoon.	Wells, 61 in use; 12 for drinking. All wells reserved for drinking for British troops have pumps; those for Natives have rope and bucket. **U. B.**	"Dry." F. C. T., S. C.
5 Fatehgarh ...	May, June and September.	End of February, April, May, June to onset of Monsoon.	Well, one in use, covered and worked by pump (bullocks). Water level at highest 8 feet from surface. **U. B.**	"Dry." F. C. T, S. C

Group VI.							
6 Shahjehanpur	July ...	*Nil.*	Wells, 25 in use ; 2 with pumps for drinking ; the rest provided with leather, bucket and ropes. Highest water level 35 feet. October. **U. B.**	"Dry." S. C.	F.	C.	T.,
7 Bareilly ...	October, but present in other months.	Strong ; March, April, May and June.	Wells, "several," sunk in bank of river, also wells in Cantonments. Pumps and pipes for drinking water. **P.**	"Dry." S. C.	F.	C.	T.,
8 Roorkee ...	April and May.	February to June ...	Wells, 4 ; two for drinking purposes have pumps. **U. B.**	"Dry." S. C.	F.	C.	T.,
9 Meerut ...	March, April and June.	May to August, not strong.	M. S. Ganges Canal water filtered and distributed by pipes. **P.** Highest level in wells 12 feet, July.	"Dry." S. C.	F.	C.	T.,
10 Umballa ...	April and May.	March to May, November and December.	Wells, 12 in use ; 9 for drinking, 3 for animals and washing. Pumps ; highest level, 14 feet, August **U. B.**	"Dry." S. C.	F.	C.	T.,
11 Ferozepore ...	June, July and August.	March, April and May	Wells 4, all pumped. **U. B.**	"Dry." S. C.	F.	C.	T.,
12 Amritsar ...	May and June	May, June and July...	Wells, 35 in constant use ; "certain" wells reserved for drinking ; 4 are supplied with pumps, others with buckets raised by Persian wheels **B.**	"Dry." S. C.	F.	C.	T.,
13 Mian Mir ...	March, April and August.	May, June and July, before the rains.	Troops get filtered water from Canal, from river Ravi ; others from wells. **P.** Wells, 40 in use, none specially reserved, rope and bucket in use.	"Dry." S. C.	F.	C.	T.,
14 Sialkote ...	Middle August to end of September.	May, June and early part of July.	Wells, none specially reserved ; raised by leathern bags and pails, carried in covered pails. **U. B.**	"Dry." S. C.	F.	C.	T.,

APPENDIX II. TO CHAPTER IV.—*Continued.*

Stations and Geographical Groups. (See also Charts.)	FLIES. In what months are flies most abundant as a rule?	DUST AND WINDS. In what months is the Cantonment subject to wind-borne dust?	WATER-SUPPLIES. Means of Raising and Distribution. Distribution { Pipes to Taps = **P.** Iron Buckets = **B.** Water unfiltered = **U.** Municipal piped supply = **M. S.**	DISPOSAL OF EXCRETA. System. Filth Carts to Trenches = F. C. T. Soil cultivated = S. C.
15 Rawal Pindi...	End of March, April part of May; October.	Strong winds with dust for the greatest part of the year.	Piped supply from river, but insufficient. Wells not supposed to be used, but when water scarce "they probably are used." **P.**	"Dry." F. C. T., S. C.
16 Attock ...	June and July.	June and July ...	River Indus. **B.**	"Dry.' F. C. T., S. C.
GROUP VII.				
17 Nowshera ...	February and March	Frequent "dust storms in hot weather."	Wells; one reserved for drinking, covered and pumped—no pipes. **U. B.**	"Dry." F, C. T., S. C.
18 Peshawar ...	May and June.	Dust storms, May, June and July.	Bara river, filtered at Peshawar, 8 miles away. Distributed by pipes to taps. **P.**	"Dry." F. C. T., S C.
19 Mooltan ...	End of March and April.	Frequent dust storms in April, May and June, occasionally in July and August.	Wells, 20; 6 for drinking, drawn by pumps (Persian wheels) **B.** Rain (6"), does not affect well. Water level, 19½ feet from surface. **U.**	"Dry." F. C. T., S. C.
20 Karachi ...	April, May and June	In Monsoon from June to August.	From river 18 miles away, conveyed by iron pipes. **P.** Highest local level of water, 2 feet.	'Dry." Carted to pits, mixed with rubbish and sold for manure.
21 Hyderabad	November to January.	Strong; April to end of August.	M. S. from Indus river (probably filtered). Highest local level of ground water, 5¦ feet when Canals are full. **P.**	"Dry." F. C. T., S. C.

GROUP VIII.				
22 Muttra ...	February, March, July and August.	April, May and June	Wells, 20 in use; 2 for drinking, covered and with pumps; the other wells used for various purposes and water drawn by leather bucket and rope; they are uncovered. **U. B.**	"Dry." F. C. T., S. C. (grass.)
23 Jhansi ...	January February, March and November.	April, May, and December to March.	Wells, 72 in use; 24 for drinking. **U. B.**	"Dry." F. C. T., S. C.
24 Deesa ...	November to February	End of March, April, May and June.	Wells, 18 in use; 2 for drinking, covered and worked by force pumps, distributed by pipes to taps. **U. P**	"Dry." F. C. T., S. C.
25 Ahmedabad ...	July, August and September.	April, May and June	M. S. Many wells, mostly covered up and not used, save when tap water is scarce. Ropes and buckets to wells. **P.**	"Dry." F. C. T., S. C.
26 Nasirabad ...	July, August, September (Bred in trenching grounds.)	Middle March to commencement of rains in July.	From a well fed by percolation from an open tank, and conveyed by pipe to reservoir. **U. P.**	"Dry." F. C. T., S. C.
27 Mhow ...	April, May, August and September.	April, May and June	From Bircha tank, 5 miles away and conveyed in pipes to reservoir (covered). Tank filled by streams from hills. **U. P.**	"Dry." F. C. T., S. C.
28 Neemuch ...	May, June and July.	May and June ...	One well reserved for drinking and cooking; pumped. Other wells for other purposes. **U. Carts.**	"Dry." F. C. T., S C.
GROUP IX.				
29 Kamptee ...	June, July, August; only plentiful where food is kept.	Occasional dust storms in April and May. Station well planted with trees.	Wells, 3 reserved for drinking, covered and water pumped to boilers; Natives who pump, stand on the imperfect covers; pumps often out of order requiring repairs. **U. B.** Two or three wells used to supply swimming bath, uncovered, drawn by leather bag and ropes. Highest level, 30 feet.	"Dry." F. C. T., S. C.

APPENDIX II. TO CHAPTER IV.—*Continued.*

Stations and Geographical Groups. (See also Charts.)	Flies. In what months are flies most abundant as a rule?	Dust and Winds. In what months is the Cantonment subject to wind-borne dust?	Water-Supplies. Means of Raising and Distribution. Distribution { Pipes to Taps = **P.** Iron Buckets = **B.** Water unfiltered = **U.** Municipal piped supply = **M. S.**	Disposal of Excreta. System. Filth Carts to Trenches = F. C. T. Soil cultivated = S. C.
30 Jubbulpore ...	May, June and July.	*Nil.*	From large reservoir 4 miles away and conveyed by pipes to stand-posts in Cantonments. **P.** Wells for watering gardens	"Dry" F. C. T., S. C.
31 Secunderabad	June, July, August and early in September.	February, March and April.	Wells, 6 in use; 3 for drinking; steam pumps. Highest level, 20 feet (December). Lowest, 40 feet (June). **U. B**	"Dry." F. C. T, No cultivation.
32 Kirkee ...	July and August	*Nil.*	From tank, 4 miles away, filtered and piped to taps. Recently in carts from Poona M. S the source of which is an open tank from which water is led in an open canal. **P.** No wells used.	Dry. Filth carts to large pits, excreta mixed in layers with straw, ashes and rubbish; after 3 months dug up and sold for manure. No cultivation.
33 Saugor ...	Very free from flies.	Comparatively free; hot weather the chief time.	Wells, 6; one reserved for drinking covered and pumped to cistern with taps. Other wells for washing, bathing animals, &c., leather bags and ropes. **B**	"Dry." F. C. T, S. C.
Group X.				
34 Colaba (Bombay city)	Singularly free, most in May.	Little or no dust. Soil rocky running into sea.	M. S Intermittent from open catchment area, miles away. Storage of each day's supply in covered iron tanks which are frequently cleaned. **P.**	Latrines have ordinary pans; excreta treated with carbolic sol.; removed nightly in carts and emptied into the sea.

Group XI.				
35 Bangalore ...	April, May and June.	March, April and first half of May.	From lake piped to Cantonments. Level of ground water varies from 6 to 15 feet. **P**.	"Dry." Filth carts to pits, where excreta mixed in layers with road rubbish and sweepings; after a month, sold as manure.
36 Madras ..	July, August and September.	*Nil*.	M. S. from tank in hills—distributed by pipes to stand-posts. **P**. Seven wells in use for other purposes only; distributed in pipes to taps; condemned for drinking purposes.	"Dry." Filth carts to be dumped on ground, 4 miles away, mixed with sweepings and sold for manure.
37 Bellary ...	October, and November.	Strong "dust storms" in April and May. Monsoon winds in May to July.	Wells, 3; one reserved for drinking, pumped to storage (pipes) and pumped thence into carts, &c. Level varies from 16 to 21 feet. **U. P.**	"Dry" F. C. T. Cultivation *to be* adopted.
Group XII. (Hills).				
38 Ranikhet and Chaubatia.	April, May and June.	April, May and June	Springs, 3½ miles away, protected by wire fences, water pumped up and piped to Cantonments. **U. P.**	"Dry" F. C. T., S. C.
39 Chakrata ...	April, May and June.	Wind, no dust ...	Spring, 3 miles away, piped to distribution tank in station. **P**.	"Dry." F. C. T. S. C.
40 Dagshai ...	May, June, July and August.	*Nil*.	Springs, 4 miles away, piped to barracks, cook-houses, &c. **P**.	"Dry." Incineration. Urine disposed of separately.
41 Sabathu ...	May and June	Dust haze from Plains, April, May and June chiefly.	Springs, 7 miles away, conducted to Cantonment by pipes. Ground-water level fluctuates between 10 to 20 feet. **P**.	"Dry." Removal by hand and incinerated. No S. C.

APPENDIX II. TO CHAPTER IV.—*Concluded.*

Stations and Geographical Groups. (See also Charts.)	FLIES. In what months are flies most abundant as a rule?	DUST AND WINDS. In what months is the Cantonment subject to wind-borne dust?	WATER-SUPPLIES. Means of Raising and Distribution. Distribution { Pipes to Taps = **P.** Iron Buckets = **B.** } Water unfiltered = **U.** Municipal piped supply = **M. S.**	DISPOSAL OF EXCRETA. System. Filth Carts to Trenches = F. C. T. Soil cultivated = S. C.
42 Quetta ...	July, August and September.	Dust storms prevail in June, July and August.	Reservoirs (fed by mountain streams) 6 miles distant, piped to Cantonments. **P.**	"Dry" Removal by trollies to deep trenches, 2 miles off. No S. C.
43 Wellington ...	Never very abundant; most in May and June.	No; sheltered by hills around.	Drinking-supply from percolation from hills filling "wells," which may be subject to pollution, piped to barracks. Other supplies led by open channel from distance of 3½ miles, subject to pollution from Native villages; a third supply to hut barracks from the channel described, but passing through wells. **U. P.**	"Dry." F. C. T.

The map facing p. 142, should be consulted.

CHAPTER V.

Epidemiology (II).

Traffic and Importation.—Camps.—Campaigns.

We are now in a position to come to closer terms with the main problem of the epidemiology, and in the Chapters which follow we shall endeavour to analyse the evidence as to the sources and the circumstances of infection ; this will lead to a final summary of the conclusions and of the practical measures of a rational prophylaxis.

In the search for a clue in a complicated enquiry of this kind it is necessary to proceed from the known to the probable, and then to bring the unknown to the test of all the available epidemiological facts. Now, in the first place, no fact stands out more clearly in the evidence and in the general considerations already presented, than the parts played by the human host as the prime source of infection, as the chief vehicle of dissemination, and as the essential stage for the maintenance of the life-cycle of the parasite by virtue of fresh infections of other more or less susceptible hosts. We have also seen how a modern short-service army, recruited from the population at the most susceptible ages, furnishes a community which, by all the conditions of its existence, is particularly favourable to the origination and extension of the disease. On the basis of the records of mortality to which the civil population is liable, we may confidently reckon that, in every body of a thousand recruits who join the colours in the United Kingdom, there may, on the average, be three or four individuals in whom the infection will be developed in more or less active form. From the outset the conditions of the soldier's life tend to promote the interests of the parasite and its dissemination ; we have all the factors induced by aggregation which may be and are, in fact, ordinarily under a considerable measure of control in the circumstances of barrack life at Home, but this short phase of the service soon merges into one of a more or less nomadic existence under the exigencies of an Empire of world-wide extent, and thenceforth, at almost every stage of the service, the dangers are exacerbated, until the operation of natural forces brings a degree of immunity to the individual, who may still, however, be a source of danger to others, less advanced on the road to this comparative safety. The shortening of the term of service, with the consequent constant flow of young and susceptible men through the ranks, has been associated with the growth of Empire and especially with its increasing responsibilities under the influence of national competition for commercial supremacy; with this there has been increased rapidity of traffic and more frequent communication between the scattered outposts, partly due to political and strategical considerations and partly to the necessities of short service and the more careful regard paid to the soldier's health (invaliding for change of climate).

We may pause, at this point, to note some of the results which have a most suggestive bearing on the argument, which will be enforced by facts to be detailed as we proceed. First, as to the presence of infection among men drawn from the civil population and mobilised as corps units, it is reported by the Commissioners who studied the origin and spread of Enteric Fever in the U. S. Camps (Spanish War of 1898) that 41 regiments, or 38·67 *per cent.* of all the corps, arrived at the camps in the Home country with cases of the disease already developed, and that in 30 additional regiments the disease appeared within fourteen days of their arrival therein. "In other words, 71 corps or 67 *per cent.* of the total had developed Typhoid Fever within fourteen days after reaching the camps;" these data being based on the "initial dates" of the first cases in 106 regiments for which the facts were traceable. It may be admitted that the circumstances were special as regards these volunteer regiments, involving as they did the rapid concentration of very large bodies of men, who exchanged their ordinary civil avocations suddenly for the conditions of a soldier's life in camp, but the same results were observed as regards the regular troops drawn from barracks, and in any case, we merely observe here on a magnified scale what doubtless happens to a less extent in the circumstances of ordinary recruitments, the smaller numbers dealt with and the conditions of aggregation modifying the results, which may frequently be overlooked when presented on a small scale. Again, at the next stage, we see a young French army sent to Algeria ; a young American army thrown into the Southern States, or more recently aggregated in concentration camps ; young British Regiments newly landed in Mediterranean stations, or in Egypt, South Africa, China and India, all manifesting alike a remarkable predisposition to Enteric Fever, and so, apart from any question of previous local sources of infection not derived from the troops themselves, we must not undervalue the evident risk of the effective transport of the infection. Such are some of the salient and best authenticated results of experience which a wide survey provides, but which are to be applied to the interpretation of more local and isolated phenomena where the true issue is often obscured by inadequate conceptions as to the nature and sources of the infection, and by a too restricted or partial view of some of the factors in operation.

In regard to the question of importation, one or two additional considerations demand attention before we proceed to the more detailed evidence. At every garrison posted along the route to India, in the Mediterranean, in Egpyt, in South Africa, the disease is constantly present to a greater or less extent, depending largely on the presence and movements of previously infected and susceptible subjects, influences as to which the Army Medical Reports afford ample testimony. As to the extent of the prevalence of the disease, so far as the records avail to demonstrate it, the following statement is of interest :—

Enteric Fever in the chief Military Outposts and Colonial Garrisons. (15 *years.*)

Garrison.	Ratios per mille of strength.			
	Decade 1888-1897		Quinquennium. 1898-1902.	
	A.	D.	A.	D.
Gibraltar	5·4	·95	3·5	1·05
Malta	6·6	2·48	7·9	2·32
Egypt & Cyprus	21·3	4·37	30·9	7·98
South Africa	12·8	1·87	(Not available).	
Mauritius	15·0	5·34	17·2	4·04
Ceylon	6·9	2·13	7·5	2·30
Straits Settlements	1·9	.88	·5	·47
China	1·5	·50	1·7	·39
India	21·8	5·75	20·9	5·56

In the next place, we have to revise our application of the text-book statements as to the period of incubation; these are at best vague and debatable and can only be used as a general indication in certain cases where the circumstances of infection can be more or less definitely traced, but in practice they are quite unreliable. A subject may be in contact with infection which may be transported on the clothing and person and there remain viable for very considerable periods before the virus attains effective access to the body and tissues of the host, and the observer who reckoned back for an arbitrary number of 14 to 21 days, more or less, from the onset of symptoms would, in such a case, be at fault in endeavouring to trace the source of the infection. The risk of erroneous deductions would be even greater if a journey had been undertaken during the course of these events. Beyond this we are still in the dark as to the possibilities of the "latency" of the bacillus in the body of the host, which may depend on the degree of virulence of the former or on that of the resistance of the latter, either of which may be altered under certain conditions to involve pathogenic effects at any time. Cases, although not numerous, yet of great significance, are on record of attacks of the disease which have occurred in jails and similar institutions at long periods after admission and where all other sources of infection could be excluded; no other cases, even of an associated nature, having been observed among the inmates for years, and the patient having been in the strict segregation of solitary confinement. Such cases are, by no means, held to be conclusive as establishing the fact of latency, but they are very suggestive, and circumstances only rarely combine to enable us to test the question fairly. We are on surer ground when we consider the undoubted fact of the persistence in, and continued excretion from, the body of the germs in the case of convalescents, and this applies to the light and "ambulant" attacks which may never be recognized as such, which, indeed, may never come under observation or may be referred to the category of "Simple Continued Fever." Now this anomalous affection is one that practically only finds a place in the army returns when the troops embark for foreign service; it is always present to a notable extent in the troopships, the rates ranging during the last quarter of a century, from 13 to 20 *per mille* on those outward bound, and from about 20 to 80 *per mille* on the passage home; moreover the rates have decreased steadily with the completer recognition of Enteric Fever as we have seen to be the case in India. The term doubtless includes cases of various etiological significance and as these cases are rarely fatal, the most certain means of elucidating the pathology are not available; but we do know that when a fatality from Simple Continued Fever occurs it is frequently found to present the usual signs of true Enteric, and when the grosser lesions are wanting we know now that Enteric or Paratyphoid Fever cannot be excluded on the negative evidence. And, again in this connexion, we have to take account of the effective transport of the virus in the persons of immune subjects who have been in contact with the sick—the so-called "*bacillenträger*" of Koch—the frequency of which has long been established in the case of Cholera and more recently in that of Enteric Fever itself. Lastly, the lesson of the South African blankets must be borne in mind; its importance can scarcely be overestimated. The evidence is incontrovertible, and who can affirm that fomites of a similar kind do not play a frequent part in the transport of infection? We must also recognize the significance of one authentic example of this kind in estimating the value of other evidence which, if not abundant, is just as suggestive; and very much has been overlooked under the influence of inadequate conceptions of the etiology of the disease.

The direct evidence of the occurrence of the disease in transports is almost certain to be defective when we consider the rapidity of modern traffic over long distances and the numerous communications with sea-port garrisons along the main routes. Infected subjects may be disembarked at any point before recognition, but they may easily leave the infection in the ship to affect others at a later stage and before the end of the voyage; similarly, drafts or reliefs picked up *en route* may introduce the infection which does not reveal itself during the remainder of the voyage. The Army Medical Reports, however, show that during the quinquennium ending 1902, the number of cases of Enteric Fever recognized on board-ship among all the troops transported was, on the outward voyage, equal to a ratio *per mille* of 2·12; on the homeward voyage, to one of 19·4, and for inter-colonial passages, to one of 11·7. The risks thus represented are very considerable, and it is notable that the record has increased very greatly during recent years. The results recorded in the Navy, may now be given for some of the chief stations during the five year period 1897-1901:—

Enteric Fever in the Royal Navy.
Mean ratios, 1897-1901.

STATIONS.	A.	D.
Home	1·25	·27
Mediterranean	3·93	·87
S.-E Coast of America ...	3·83	·21
Pacific	3 81	·21
Cape & W. Coast of Africa ...	8.14	2·42
East Indies	6·83	1 2
China	5·14	1·06
Australia	3·15	·46

About 60 per cent. of the total force were under 25 years of age, a proportion fairly comparable to that obtaining among the troops. The extent of the prevalence of Enteric Fever in the Mercantile Marine, may be indicated by some figures kindly furnished by the Medical Inspector of the P. & O. Company; during the three years ending 1904 the number of attacks among the European crews gives an annual rate *per mille* of 3·1, but the men exposed are, as a body, beyond the most susceptible age ; they are, however, kept under supervision by the same surgeons for longer periods than is the case with the troops at sea ; the former are also more "seasoned" and are not subject to such constant reinforcements of young and susceptible subjects at the several ports *en route.*

The troops, moreover, are specially exposed to the influences of aggregation and to other disabilities on board, and where infection is present, as indeed it must generally be, its dissemination is favoured by the mingling of the components of several corps units and their final distribution to various destinations after disembarkation.

In proceeding to a survey of the evidence bearing on the question of the transport and importation of the disease, it must be remarked at the outset that, in view of the prevailing conceptions of the infective process and of the sources of infection, only the most obvious and striking instances have been put on record ; then, again, of these it is only possible to give a more or less random selection from the annual compilations, the reports of the Medical Officers immediately concerned not being now available. At the same time, the epidemiological analogies presented by other infective diseases must be borne in mind, a subject too wide for discussion here and scarcely necessary to the professional reader ; we may merely point to well-accredited instances in the cases of Malaria, Cholera* and Dysentery, and give one recent example.

* The history of Cholera is especially instructive in this connexion, from certain analogies presented by the two diseases; the long controversy on the Quarantine question affords the best support to the view set forth here. Where they differ, as in the longer incubation period and more insidious onset in Enteric, the argument from the experience of Cholera gains greater force.

At the meeting of the Société Médicale des Hopitaux de Paris on October 28th, 1904, Professor Dopter of Val-de-Grace, brought forward cases to show that in France, contrary to what was supposed, amœbic dysentery may be transmitted from patients who have contracted the disease abroad. He related five cases of soldiers in colonial regiments who had never been abroad, but who evidently contracted amœbic dysentery from comrades who were infected in tropical countries. In one case a soldier, aged 23 years, was admitted into hospital suffering from dysentery. Microscopic examination of the stools showed numerous very mobile amœbæ which were crammed with red corpuscles. The bacillus of dysentery could not be found and the agglutination reaction for it was negative. Intra-rectal inoculation of a young cat produced typical dysentery from which it died after presenting amœbæ in its stools. Sections of the large intestine showed amœbæ in the glands of Lieberkühn. Inquiry revealed the fact that in the same company as the soldier in question was a man who slept in the same room, separated by two beds, and suffering from a relapse of amœbic dysentery contracted in Cochin China. In the other cases the disease appeared to have been contracted similarly from soldiers sleeping in the same room. (*Lancet*, December 3rd, 1904.)

No more instructive lessons in regard to the transport of Enteric Fever are to be found than those scattered through the pages of the Army Medical Report of 1882, the year of the campaign in Egypt, when the morbidity rate from the disease, during and subsequent to active operations, amounted to no less than 92·8 per 1,000 of the strength exposed. The Director-General, A. M. D., says :—

> "The long period of incubation exhibited in many instances by patients suffering from this fever is worthy of record. The brigade of Guards left Alexandria (for Home) at the end of October (from October 30th to November 2nd), and cases of Typhoid Fever continued to be admitted for nearly nine weeks after that date. Even supposing that the disease was contracted on board-ship, the incubation is a long one. That the disease was of Egyptian origin, and not due to infection from one to another in this country (United Kingdom) seems highly probable, because the spread of it was confined to those who had been in Egypt." (page 117.)

In the same year, we find the disease giving a rate of 35·3 *per mille* among the troops in Cyprus ; it is said that

> "the second case (of a total of 21) happened in a man who contracted the disease in Egypt, and the succeeding 11 cases, with one exception, had a similar origin." But it is added that the whole garrison "had served in Egypt and had recently arrived thence ;" * * * "there can be no doubt that

all these attacks were the result of service during the campaign in Egypt." (page 50.)

Turning in the same Report to India, we find it stated under the head of Bombay,—"there were 9 cases and 4 deaths; of these 8 were received from the 2nd Derbyshire and 2nd Manchester Regiments on board H.M.S. *Euphrates* from Alexandria in October." (page 101.) In the same year, of an outbreak of 43 cases at Sitapur, to which 19 more are to be added which were later transferred from the head of "Simple Continued Fever," Sir A. Home remarks:

"The garrison of Sitapur at the time consisted of a half battalion of the Lincolnshire Regiment, which corps had disembarked at Bombay on January 28th, 1882, its previous station having been Gibraltar; a draft of 97 men had come straight from England in the troopship which at Gibraltar embarked the regiment for passage to India. It is presumed that the men of the draft, those of the service companies, and also the women and children, embarked in perfect health, and it is not known that any Enteric Fever case had previously existed among them; and there is no record of the occurrence of Enteric fever amongst other bodies of men embarked on the same troopship on this voyage. On disembarkation, after having remained a few days at Deolali, where it was reported quite healthy, the regiment proceeded by wings up-country, on different days, by railway, one wing to Benares and the other to Lucknow; as far as Allahabad both wings were quartered in the same rest camps at night, but successively and at intervals of two days. On the 6th the right wing left Allahabad for Lucknow, whence it proceeded by route march to Sitapur, arriving on the 13th."

"During the progress of this wing from Deolali to Lucknow the men were healthy, but it is reported that one man was transferred to hospital at the latter place suffering from tonsillitis, and that of the five men sent to hospital on arrival at Sitapur three of them were suffering from tonsillitis, and one from Simple Continued Fever. Both of these illnesses are of significance; nothing is more frequent than the connexion in time between a preceding tonsillitis and a following Enteric fever attack. Leaving out of view the question of the connexion between them, the occurrence of these cases is sufficient, in the judgment of the writer, to give grounds for assuming that the outbreak of Enteric Fever which soon occurred in the men of the wing at Sitapur was in causation due to something not intrinsic to that station; but the fact must be stated that an admission of Enteric Fever had occurred in the end of January, in the case of a man of the corps relieved by the wing of the Lincolnshire Regiment. The outbreak in the latter dates from the 23rd February (*i.e.*, 26 days after landing in Bombay) on which day a man was admitted with an illness supposed to be Simple Continued Fever, but which afterwards proved to be Enteric Fever. The epidemic terminated in the week ending 9th June.

We need only add to the above account that during 1881 there had been 730 cases and five deaths from Continued fevers in the garrison at Gibraltar, as to which the Medical Officer remarks:—"possibly there may have been an error in diagnosis as severe cases of local fever, complicated with diarrhœa, very closely resemble Enteric and it is only at the *post-mortem* that the real nature of the disease is discovered."

Further, these numbers rose in 1882 to 861 and 4, and, in addition, 40 cases of Enteric Fever were recognized of which 8 proved fatal; and constant changes were made in the *personnel* of the garrison during these years owing to the campaign in Egypt. It should be noted that we have been dealing with the events of one year and the record, when combined as in these extracts, is extremely significant, and could doubtless be supplemented by other instances if the facts were available; but those we have are isolated experiences recorded by different observers posted at various points along the whole distance from England to India, and their value is enhanced by the consideration of the independent character of the testimony and the absence of any consentaneous aim to substantiate a theory of dissemination. When also we note the prominent position occupied by Egypt in the list of Enteric Fever rates already given, we may appreciate the importance of this "half-way house" on the road to India (involving a sea-voyage of some twelve days only) in regard to the risks of importation of the infection; for what is shown to occur on a large scale, occasionally, doubtless occurs constantly to an uncertain degree.

The importation of two cases of the disease into Cyprus from Malta ("the men sickening at sea") is definitely recorded in the Report for 1881 (page 39).

In 1885, an outbreak at Suakim "was attributed to the arrival from England of a draft of young soldiers for the Shropshire Regiment," and we shall allude to this case more fully when we come to deal with campaign influence.

In 1887, it is reported of the disease in the Straits Settlements, that

> "two of the six cases occurred in men who had recently arrived from the Cape; several cases are said to have occurred among the crew of the ship. There were 45 cases of Simple Continued Fever." In the same year it is reported as regards Malta: "the disease prevailed in June, July and August in the West Kent Regiment, the R. E. and the South Staffordshires. The first-named corps arrived from Egypt on 16th June, and cases were admitted daily from all companies of the regiment up to the middle of July. The disease in this corps was evidently contracted in Egypt, and it is believed that very few, if any, cases originated in the garrison (Malta)."

As regards Egypt in the same year, the decrease in the disease is attributed to the stationary location of the troops at the different posts in that country during the year ; the garrison was "not as in previous years a fluctuating population passing up and down the Nile." There is, it may be remarked, a close parallel between the circumstances attending the occurrence of Enteric Fever and Malarial affections in Upper Egypt, this depending largely, if not entirely, on the traffic up the river and the transport of infection ; the periods of incubation in these diseases are sufficiently alike, and, as we shall see, there is good reason to believe that neither prevails in endemic form beyond the limits of Lower Egypt. The suggestion conveyed by the above-quoted statement is valuable, because elsewhere modern lines of traffic are far more complicated and so the results of movements between different cantonments are obscured, and all connexion is overlooked, or at least the clue to origin is missed.

Coming to more recent times we find various instances cited of the transport of infection from stations in England to Ireland and *vice versâ* (A. M. D. Reports, 1897-1898). In 1897, a regiment that had been occupied in manœuvres carried the disease in its progress from Birr to the Curragh, to Cork and Fermoy. In 1898, it is said that the prevalence of the disease in the army in the United Kingdom was largely influenced by the return of the men from the Khartum expedition among whom there occurred, after arrival, 90 cases. The returns from Cairo and Alexandria show 394 cases during the same year, but of these no less than 291 are reported as "contracted Up-Nile" on active service. The periods elapsing between the dates of the return of the patients from "Up-Nile" and the development of the attacks is stated as follows :—within first week after return, 45 cases ; second week, 58 ; third week, 80; fourth week, 60 ; fifth week, 18 ; sixth week, 18 ; seventh week, 11; eighth week, 2 cases.

In 1900, it is remarked as regards the disease in the United Kingdom, that in one or two instances the patients had recently returned from South Africa. In 1901 an outbreak at Portland was ascribed on very cogent evidence to the occupation of certain overcrowded casemates by invalids from South Africa from whom it was transferred by direct contact to other men in association with them (see also Lt.-Col. Davies in *Journal R.A.M.C.*, June 1905). In 1902, of the 114 cases recorded in the United Kingdom, 10 were contracted abroad or on board-ship ; and in 1903, of 27 cases at Aldershot, it is said that 16 were probably contracted in South Africa.

It would be tedious and it is unnecessary to pursue similar references farther. As the question has only forced itself upon the notice of medical officers at the port of disembarkation, and Bombay is practically the sole gateway to India, we must certainly conclude that very many instances of importation from troopships have never been reported. In a recent (1905) communication to the writer, the Officer Commanding the Station Hospital, Bombay, says that the small amount of Enteric reported from that place is not contracted locally; "all cases come from the troopships." There are numerous references to, and decided statements on, the point in nearly every issue of the Sanitary Commissioner's (India) Reports since 1895, *e.g.*, in that for 1895 (page 30), "three men disembarked with the disease on them;" 1896 (page 28), "some 9 or 10 men were supposed to have contracted the disease on boardship, at Bombay, or on the way to up-country stations;" 1897 (page 29), "three men appear to have contracted the disease before they landed in India;" 1898, a precisely similar remark; 1899 (page 27), "in two Calcutta cases, the infection is said to have been probably contracted in South Africa;" and so on. Of an outbreak at Agra in 1897 (181 cases) it is said that it was due partly to the fact that the 2nd York and Lancaster Regiment, which was chiefly affected, had arrived from Mauritius and South Africa on February 21st and 23rd, on which dates an officer and some men showed symptoms of the disease. At Umballa, in 1903, after an outbreak in the early months of the year, the disease disappeared early in July and no case was recorded till the last week of October, "which was directly after the arrival of the Oxford L. I. and the 2nd North Staffordshires from England." The former corps arrived in Bombay on October 15th, the latter on October 26th, and between them 21 cases were furnished during the remaining two months of the year. Again, in several years in discussing the relative incidence on corps units, the Sanitary Commissioner mentions incidentally that those occupying the first places in the Enteric list had just arrived from some foreign station, and Egypt, South Africa and Mauritius are among the most frequent examples. In the A. M. D. Report for 1904, it is reported that a small epidemic of 7 cases occurring at Nowshera (Punjab) was attributed to importation of the infection by a draft of men from South Africa "who contracted the disease on boardship, or on landing at Bombay."

In concluding these references to importation from outside India we find forcible evidence in the experiences attending the transfer of corps units and of bodies of Boer prisoners from the seat of war in South Africa. In the Sanitary Commissioner's Report for 1902 (page 19) it is said that "a certain number of cases were contracted on troopships which had been constantly conveying troops, many of whom had recently suffered from Enteric Fever, to and from South Africa;" and that "the disease was introduced into some stations by Boer prisoners of war who were brought to India while suffering from the disease." Instances are given of such cases at Colaba (port of Bombay) and Madras; as regards the latter, it is said that

> "four cases were admitted direct from the transport and a fifth a fortnight later; an increase in the number of cases occurring among the British troops in the Fort followed the admission of these cases. At the Boer camp at Kakool the introduction of the disease by the Boer prisoners is also given as the reason for the origin of the cases among the troops, and at Wellington most of the cases occurred among men quartered in Kaiti camp, as a guard over the Boers, among whom the disease was very prevalent."

Let it be noted in passing that these different bodies of Boer prisoners were strictly guarded and isolated in sanitary camps, and that they had no access to the native towns and bazaars which are commonly held to be the chief, if not the sole, sources of the infection for the British troops; this is a point of great epidemiological interest and importance as bearing on the sources of infection to which we shall refer later.

Next, in the same connexion, we have the convincing evidence of the importation from South Africa of the disease by Boer prisoners into the camps in Ceylon, and the subsequent transmission of the infection to their British guards. A full account of this classical instance is given in the report of Sir Allan Perry, the Principal Medical Officer, Ceylon, together with a paper by Lt.-Col. Quill, R.A.M.C., in the *British Medical Journal* of February 15th, 1902, and in the A. M. D. Report for 1900. The total number of Boers attacked from September 2nd to November 29th, 1900, the date of the last case, was 711, and it is made clear on the evidence, that the first case was infected before arrival in Ceylon. Sir Allan Perry adds that the bare facts are "that a large body of men (5,000 in all) were transported from one continent to another; they were located in a perfectly new camp town far removed from other habitations of any kind (at Diyatalawa on virgin soil, in an excellent climate 4,140 feet above sea-level), which had been built expressly for them with a good water-supply and excellent sanitary and conservancy arrangements ; and that they had not been there more than three weeks when Enteric Fever occurred, and ran through the community at an alarming rate." He then sums up the evidence which leaves no shadow of doubt of the fact of importation from South Africa by the prisoners themselves, and as regards dissemination, he indicates the probability of direct infection by means of the latrines in common use, and he alludes to the possibility of the action of flies. The uncleanly habits of the Boers favoured dissemination by the transport of infection in excrement on the person and clothing to the huts ; "the possibility must also be recognized of the germs of the disease being in the system before arrival in Ceylon, and remaining inert until, by deterioration of health or under favourable conditions, they lighted up into activity and produced the disease."

The following further details as furnished by Lt.-Col. Quill, R.A.M.C., are of great interest (A. M. D. Report, 1900, page 449). A site for the camp was chosen in the "Happy Valley," 4,600 feet above sea-level and some four miles from Banderawella. An ample and pure water-supply was obtained from the hills three miles distant, being conveyed to the camp by iron pipes underground. The camps for the prisoners and their military guard were ready for occupation at the end of July, and on August 9th the first batch of Boers, which had landed at Colombo on the previous day, arrived at the camp. These were followed at short intervals by successive contingents as the transports arrived, until by November 9th the total number under guard amounted to 5,028 officers and men.

> "On September 21st one of the prisoners who had arrived in Ceylon on 5th *idem* was found to be suffering from Enteric Fever of probably 10 or more days duration, and this was the commencement of an epidemic which quickly assumed formidable proportions. By the end of December, 600 cases of Enteric had been diagnosed and during the same period there had been also some 200 cases of Simple Continued Fever, many of which were doubtless Enteric Fever in a mild form. That this epidemic among the prisoners had been imported from South Africa is open to no reasonable doubt. Not only had the disease been rife among the Boer forces, but the transports which brought the men to Ceylon had left ports in South Africa where Enteric Fever was raging. Many cases occurred on the transports during the voyage to Ceylon and from one vessel alone 9 cases were landed and sent to the General Hospital in Colombo.

In this vessel, be it noted, the individual had travelled who presented the first case recognized in the camp.

The results of this outbreak among the Boers on the guard furnished by the King's Royal Rifles are next given in full and instructive detail which space does not permit us to quote, but the original report should be consulted as a most careful and valuable contribution to our knowledge of the epidemiology of Enteric Fever. The circumstances provided all the conditions of a scientific experiment, and the discussion of the various factors ordinarily associated with outbreaks of the disease shows that the arrangements and the sanitary conditions of the camps were as nearly as possible irreproachable, until infection was introduced by the Boers. The conclusion is arrived at, on evidence which it is difficult to refute, that the infection was conveyed by dust and probably by flies from the contaminated latrines in the Boer Camp, the troops on sentry duty "being in close contact not only with the prisoners" (a barbed wire fence intervening) "but with their latrines, urinals and wash-houses."

The significance of these well-authenticated instances of importation by the Boers to India and Ceylon is enhanced if we look to the results which ensued in the other colonial stations to which these prisoners of war were deported. We shall find almost precisely the same sequence of events following the arrival of the remnants of Cronje's army at Deadwood Camp in St. Helena. And in 1902 all the main features of the Ceylon experience were reproduced at Bermuda, West Indies; the disease was introduced by the Boers and by the British Regiment in charge of them, and an epidemic broke out which affected chiefly the men of the Worcester Regiment composed of young men who had recently arrived direct from England; the infection spread to the Naval forces in port at the time with disastrous effects (Cockerill, *Journal R.A.M.C.*, June 1905).

If more evidence were needed, we should find it, doubtless, in the records of the hospitals at the chief Indian seaports, if all the facts of the occurrence of the disease among British and foreign seamen were available. Hirsch notes that ships' crews frequently suffer from Enteric Fever in tropical and subtropical ports, but he conveys the inference that the disease is there endemic without affording evidence for this assumption. Leaving that question aside for the present, there is still conclusive proof of frequent importation, if regard be paid to the relation between the dates of arrival at the port and those of admission of cases to hospital. This is borne out by a return of the cases treated from 1890 to 1904, in the

Presidency General Hospital, Calcutta, with which I have been favoured by the kindness of Major Pilgrim, I.M.S., the Surgeon-Superintendent. In no less than 48 cases out of a total of 81 seamen admitted, the patients were attacked within a period after arrival at Calcutta, which was less than that ordinarily ascribed to the requirements of incubation, 40 of the number within 10 days of arrival, and many were immediately landed and taken to hospital. One instance may be cited, that of the crew of the S.S. *Fort Salisbury* which had come from Durban in 1900, the voyage to Calcutta occupying about 22 days. There can be little doubt from the circumstances that the first infection was acquired in South Africa, but the disease was not recognized; the patients were allowed to work until no longer able to do so, and thus infection was spread among the crew (there were no passengers) with the result that fifteen cases were admitted to hospital on arrival at Calcutta, there being also five or six mild cases besides that never came under treatment.

The space at disposal does not permit of a discussion of the evidence of the importation of the disease from one colonial station to another. A good example is furnished by the history of St. Helena, where formerly a case of Enteric Fever was a very rare occurrence, in spite of the unfavourable conditions in which the troops were located. Reference has been made to the results of the transportation of the Boer prisoners from South Africa to St. Helena and to Bermuda. There are also well-authenticated cases of importation by the British troops arriving in relief.

We may pass on to consider a few typical examples of the transport of infection by individuals and corps units from one place to another, whether camp or cantonment, after arrival in India.

In nearly every more recent issue of the Annual Report of the Sanitary Commissioner (India) the remark appears that "the disease must have been contracted by newcomers before arrival at the reporting station, from impurities encountered *en route* or from a cause existing in a previous station or rest camp;" this also is the almost invariable report from the Hill stations, and the same experience is frequently noted as the result of the return of the troops from their summer sojourn in the Hills, as also of the arrival of drafts and reliefs and of the transfers of regiments from one station to another, which are a constant feature of the arrangements during the winter months.* These facts have already been alluded to as determining, in part, the rise in the seasonal incidence which is shown in the charts at this period of the year. This phenomenon was very early recognized, as indeed it could scarcely have escaped the most casual observer, and it gave rise to the application of the epithet of "infected regiments," from the recognition of the fact of the adhesion of the infection to certain corps which were observed to carry the disease from place to place, the members of such corps always suffering a notably distinctive, if not exclusive, incidence wherever located. Briefly, a broad but obvious distinction could be made at all times between a general local or place infection, by which all were more or less indiscriminately affected, and that which was associated with particular sections of the *personnel* in any one place at the time, a forcible demonstration of the influence of the human host factor and of the true sources of infection. Examples:—as far back as 1878, we find the following statement of the experience of the 4/60th Regiment; it embarked from England on 2nd November 1876 and arrived in Bombay in December, proceeding to Agra where it was quartered in the cantonment with a detachment in the Fort. In the course of the next year, it was distributed as follows:—Agra, 583 men; Dagshai, 80; Landour, 51; Naini Tal, 21; with two men each at Kasauli and Chakrata. At Agra Fort, five deaths occurred; at Dagshai, where the aggregate strength of various corps was 1,125, the men of the 60th Regiment, only 80 in number, yielded seven cases out of a total of eight in the station; at Landour there were two cases in the detachment (51 men). The Medical Officer of the regiment proceeds to allude to the water-supply as the source of the outbreak, but the Director-General remarks "it is necessary to bear in mind the cases which were occurring elsewhere in the detachments before attributing the disease at Agra to the causes assigned for the outbreak there."

Again, in the same Report (1878), we find it stated that the 73rd Regiment had suffered from Enteric Fever in Colombo in 1873, that the disease maintained its hold on the men on their transfer to Cawnpore in the following year, with an increased prevalence in 1875, after which the corps was moved up to the Hill station of Sabathu for two years, during which the disease steadily claimed larger numbers of victims, there

* In the Report of 1899, there is an allusion to the "dirty state of the carriages provided in the troop trains running from Bombay."

being always a heavy return of Simple Continued and Remittent Fevers in addition. For a period of nearly six years the 73rd "has not been free from Enteric Fever: the regiment was fever-stricken, the fever being endemic *in* the regiment" (page 289). In discussing the influence of local causes reference is, as usual, made to the water-supply and to the insanitary state of the site (at Sabathu), and it is added, "there was some overcrowding of the men in Barracks;" and, "there was not that amount of segregation and dispersion of the sick that was desirable."

In 1879, there occurred an outbreak in the 70th Regiment which in the early part of the year was at Multan, but which proceeded to Sabathu and Dagshai (Hills) in the summer, a detachment being sent on in advance to arrive in April, the head-quarters arriving in May. There were altogether 34 cases and nine deaths recorded in the corps during the year, the first occurring, *i.e.*, recognized, on March 26th at Multan before any of the men had left that station. There were then six cases admitted on the way up to Sabathu, where ultimately 24 more cases occurred, the first being admitted there from the advance body on April 21st, but the chief outbreak was in July and August. This was confidently attributed to the consumption of diseased mutton and has been frequently quoted as an instance of food infection, a theory which was based on the facts that the sheep from which the meat-supply was obtained were suffering from a wasting disease of the bowels and that the outbreak among the troops ceased on the stoppage of the issue of this particular meat for the ration. It is satisfactory to note that, even at the time, this theory was officially criticised, and the conclusion arrived at was: "it is evident that the disease cannot be said to have been originally contracted at Sabathu, but was, in fact, carried there." It may be added that among the men sent to Dagshai three cases of the disease were also recorded during the same period.

The next Report (1880) gives the following account of the experiences of the 30th Regiment, which landed in Bombay on February 9th and reached Bareilly on 17th *idem*, detachments being sent to Moradabad and Shahjahanpur. It had been proposed to institute an experiment by observing the results as regards Enteric Fever on one or two corps which it was intended to despatch direct from Bombay to the Hills without a halt at any station *en route*, and the 30th was selected to undergo the trial, but the Afghan war intervened and prevented the arrangement being carried out in its entirety. The disease broke out while the regiment was encamped at Bareilly in February (four cases), and early in April it marched through the Tarai, along a route which had not been traversed by troops for 20 years, to Ranikhet (Hills), leaving about half its strength distributed in Bareilly, Moradabad, and Shahjahanpur.

> "Several cases of Remittent Fever of "a severe form," and four of Enteric (two fatal) occurred during this march. The disease clung to the head-quarters after arrival at Ranikhet; it also prevailed among the detachments at the three plains stations above-named. Of the total number of 65 cases, 30 occurred in the plains and 35 at Ranikhet." (Page 86.)

Again, we find frequent instances of the following kind; a regiment located in the plains sends a considerable proportion of its strength to the Hills and then Enteric Fever appears simultaneously in both parts of the corps in places as widely separated as Lucknow and Ranikhet; and yet another body of men in the latter station of similar age and service constitution, but belonging to other corps, entirely escapes any overt manifestation of the disease. The troops infected, in one case in point (1886), had arrived at Ranikhet in April when the disease was prevalent in the head-quarters at Lucknow, whereas the rest of the men at Ranikhet (the non-infected body) had arrived from Lucknow in the previous January. It may also be noted that there was free intercommunication of these two bodies of men; they visited each other and frequently ate and drank together in their respective lines, and the general conditions of the environment, water-supply, &c., were practically identical, and yet only those suffered who had been exposed to the infection in the plains and who had brought it with them to the Hills. Had the other body of men been detained in the plains until the disease broke out at the usual season, they would, doubtless, have exhibited the same results as their station comrades. We may merely remark in passing that an unpremeditated experiment of this kind—of frequent occurrence—makes it difficult to fall in with the prevailing view of ubiquitous infection beyond the immediate environment of the barrack sites, such as might be expected from the widespread prevalence of the disease among the natives.

If it were necessary to multiply instances, many more are to be found in the successive reports of the Sanitary Commissioner (India), the experience of the Hill stations being specially favourable to a clear appreciation of the course of events. In 1897, the Medical Officer at Chakrata says :—

"A number of men contracted the disease before arrival at this place. Urgent warnings concerning the dangers of the road to Chakrata were issued before the departure of the men from the plains to all Commanding Officers as well as to the Medical Officers concerned, urging the adoption of stringent precautions and pointing out that during the previous few years some 135 cases had probably had their origin on the line of march. All water and milk were consequently boiled at every stage upon the road ; the men were warned against eating vegetables and bazaar products and no hawkers were allowed to visit the camps. At Chakrata and Kailana the water-supply was carefully investigated before the arrival of the troops in March ; samples from numerous points of the system were pronounced to be bacteriologically pure and nevertheless, all water and milk obtainable by the men was ordered to be boiled. Later on in the season, samples of the water were again examined and found to be "pure."

There were, however, in all 54 cases of Enteric Fever which, on a strength of 749, yield a ratio *per mille* of 72 ; the troops brought the disease with them, the monthly incidence of cases being as follows : March, 6 cases ; April, 25 ; May, 14 ; June, 24 ; July, 15, followed by a rapid decline.

In 1899, Lt.-Col. Davies, R.A.M.C., in reporting on the sanitary state of the same station, refers in strong terms to the dangerously polluted state of the rest camp sites on the road. "At Chakrata in 1899, there were 75 cases of Enteric, of which probably 29 were introduced, probably from the line of march, only five cases, in my opinion, originating in Chakrata, the remaining 41 cases occurring in Kailana (close by) where the disease spread owing to faulty latrine arrangements and to the close proximity of the latrines and cook-houses. Infection once introduced into the latrines, it spread owing to their bad structural condition and to faulty conservancy."

"At Rawal Pindi a draft was undergoing segregation for a month under canvas away from the head-quarters of its regiment. Towards the end of the period of segregation a case of 'fever' was admitted into hospital from this draft, and remained under treatment with a suspicious temperature. The men of the draft were allowed to go into barracks at the end of their month of segregation. Some short time afterwards, first three, and later twelve, men of the same draft were admitted in hospital suffering from Enteric Fever ; these latter were considered to have contracted the disease from the latrine infected by the first 'fever' case which by this time had been diagnosed Enteric Fever." (A. M. D. 1904.)

These instances have been noted at random in running through the records for other materials, and others will be given incidentally when we come to deal presently with the

Hill stations. They will suffice as typical examples of similar experiences constantly recurring, and even if they stood alone their importance could scarcely be exaggerated, for it must always be borne in mind that for one instance, such as those cited, which cannot fail to impress the observer intent on purely local sources of infection, there must be an untold number of less obvious cases of importation which evade detection ; and a single infected individual may easily spread the virus throughout a community of susceptible subjects in aggregation, in one or more of the ways already indicated. If now we look to the records of the disease among the troops during the annual cold weather movements, marching on relief and to and from manœuvres, &c., we find some significant evidence ; the following statement is compiled from the Annual Report of the Sanitary Commissioner and gives the facts recorded for the combined period 1895-1903 :—

Enteric, Remittent and Simple Continued Fevers among the Troops "Marching," 1895-1903.

1895—1903 (9 Years.)	Ratios per mille of strength.					
	Enteric Fever.		Remittent Fever.		S. C. Fever.	
	A.	D	A.	D	A.	D.
Troops Marching, in all Commands.	15·3	0·54	11·5	·08	7·3	—
All India, excluding troops marching. ...	23·4	6·18	14·1	·29	28·5	·03

The figures demonstrate, first, the fact of the prevalence of the disease among the men in passing from one cantonment to another or to camps along the main lines of march. At the same time, there is, apparently, a very appreciable diminished incidence on the men when they leave their cantonments. But we have to remember that only those who are apparently in good health are despatched on marches and to manœuvres, camps of exercise, &c.; and then again, it is obvious from the respective mortality rates, shown in the table, that many cases occurring on the march are dealt with and recorded only at some head-quarters station, to which the sick are transferred, or which are only recognized on arrival thereat. Furthermore, these marching operations almost invariably take place during the winter months, one of the periods of least prevalence, and the comparison, be it noted, is with the incidence within cantonments throughout the year, including the periods of maximum prevalence. It can scarcely be doubted that the distinctive incidence, such as it is, on the winter months, is very largely due to these marches and movements and that if they were not undertaken we should find this period one of comparative freedom from the disease.

Again, if the annual records be referred to, we find important indications of importation from places where the disease was specially severe and widespread, *e.g.*, under the influence of campaigns. In 1897 (Tirah Campaign), the marching returns from the Bengal Command gave an admission-rate from Enteric Fever of 55·4 *per mille*, those of the Punjab, one of 64·6 *per mille*, these being the areas chiefly drawn upon for the troops engaged in the operations (compare these rates with those given in the table above). We must, therefore, conclude that we get evidence here not only of the transport of infection, but of special liability of the men to contract it under the circumstances of life upon the road and in the camps they occupy in the course of their movements. These circumstances are generally summed up by prevailing opinion, as those arising from closer contact with the insanitary environment of the native population. We have already alluded to this view of ubiquitous sources of infection outside the limits of cantonments, and shall deal with it more fully in a subsequent Chapter. The evidence already presented and more to be given in the sequel will, it is contended, make it impossible to rest content with this explanation, to the exclusion of other considerations of the greatest weight. The theory is seductive by its very simplicity and it removes the onus of prevention beyond the control of those responsible for the health of the men within cantonment limits ; it appeals to those who still believe that all is at its best in the most sanitary of all places, the Indian cantonment, but it is also based on an inadequate appreciation of the natural history of the infective agent, of the chief sources and modes of dissemination. It has also been fostered by a persistent tendency to regard the disease in India as a phenomenon distinct in its origin and in many of its manifestations from those it presents elsewhere, and notably in non-tropical areas; the mere fact that it is constantly alluded to as "Tropical Typhoid" is significant of a confusion of ideas on the subject, and the records of the disease in India are replete with controversial discussions of this crucial point of the etiology, *viz.*, its essential identity everywhere under different conditions. We have seen that there is little justification for any doubt on this point even when the survey is confined to India, but we have been at pains to take a more comprehensive view, and the evidence drawn from experiences elsewhere should demonstrate, beyond all question, that the same essential factors are in operation here and that there is no need to invoke any special influences, though we any not deny to them a special force.*

This is again clearly brought out in the history of the disease in connexion with the concentration of men of the soldier's age in camps, military, mining and other, from which we shall draw a few of the many instances, the only difficulty being to select and to condense them within due limits. The bearing on our main thesis will be evident not only from the abundant examples of camp outbreaks to be found in the Indian records, but also because, as has been pointed out, the general conditions of our cantonments approximate in most essential respects to those associated with life in camps. A study of the evidence afforded by the records of camp outbreaks leads clearly to certain general conclusions which may be briefly stated at the outset: first, there is frequently evidence of importation of the infection; secondly, the conditions of camp life are eminently favourable to the propagation of infection; and thirdly, a body of infected men on evacuating a camp, not only leave the infection behind them, either with their sick or in the external environment, to affect other bodies subsequently occupying the site, but they carry it with them in their progress, in the persons of the sick, of convalescents and of unrecognized cases; in clothing, baggage and equipage. In the foregoing pages we have given, incidentally, examples of these phenomena which are entirely in keeping with the etiological considerations with which we set out. To the reader desirous of pursuing the subject we would commend the "Report on the origin and spread of Typhoid Fever in U. S. Military camps during the Spanish war of 1898," issued by authority at Washington in 1900, than which no more valuable and suggestive contribution to our knowledge of the epidemiology of the disease in armies on mobilization, has ever been published. It would be impossible to give in the space at

* It may be noted however that paratyphoid infections are included in this statement, and doubtless much of the Enteric Fever recorded should rightly be included in the paratyphoid category (see Chap. III).

command the barest summary of the detailed evidence presented in this Report on all the main points of the contention just set forth as regards the characteristic features of camp infection ; no one interested can, at any rate, afford to neglect a close study of the "Abstract" of the Report which has been issued separately and to which a few references may be made.

As regards importation, we have already given the conclusions of the Commissioners as to the proportion of the Volunteer regiments that mustered in camp with the infection already developed among the men (see page 226). Next, we have evidence of the freedom from the disease of the regular troops in barracks before mobilization took place, and then of the outbreak of Enteric Fever soon after the arrival of recruits to these corps and their concentration in camps (page 172 "Abstract Report"). "Typhoid Fever becomes epidemic both in the small camps of not more than one regiment, and in the larger ones consisting of one or more corps." A large proportion (about one half) of the cases was not recognized, and this refers especially to the first infections ; of these, many of whom were invalided for anomalous fevers, the diagnosis was only established on subsequent admission to Civil hospitals at their homes (pages 190, 173). From exact data detailed it is concluded that:—

> "there is no constant relation between the number of men infected at the time of going into camp and the number that develop the disease beyond those previously infected within a given time. The means for the spread of infection must vary in each command and camp" (page 12).
>
> "Every regiment that arrived at Camp Meade, Pa., whether coming from another general camp, or direct from State camps, imported Typhoid Fever. There was no exception to this statement. Of 25 regiments that reached Camp Meade during the latter half of August and the first half of September, 18 were thoroughly infected and 7 had already had from 2 to 8 cases of the disease" (page 119).

Similar statements are made as to the camps at Mobile, Ala. and Panama Park (pages 133, 138).

> "There is an apparent tendency in men to believe in the evil genius of locality but no fact in our investigations has been brought out more prominently than that locality was not responsible for the epidemic among the men of the 15th Minnesota. This corps first developed Typhoid at the fair grounds of St. Paul: there is no evil 'climatic influence' connected with this place. It carried the epidemic with it to Fort Snelling, which has long had the reputation of being one of the most healthy army posts in the United States. From Fort Snelling the corps was transferred to the open fields of Camp Meade. However, Typhoid Fever continued in the command because the men carried the germs of the disease in their bodies, clothing, bedding and tentage" (page 176).

Details of similar experiences among the regiments of the 7th Army Corps are given on pages 134-135.

As regards the infection of camp-sites, we have also a large body of evidence. The second division of the first army corps at Chickamauga was almost certainly infected by means of specifically contaminated water; "we see no reason for believing that these wells from which the drinking-supply was drawn" (described) "were infected when the troops arrived"; all the evidence was to the contrary:—

> "The troops brought the disease with them, infected the water and then drank it. But water was not the only means by which the disease was spread at Chickamauga. Like all other organizations in the park at the time, the camps of the regiments became terribly polluted. Sinks (trenches) could not be properly constructed; their contents were not kept covered or even kept within bounds, but overflowed and polluted the soil around. Flies swarmed alternately about the trenches and mess tents. Men carried infected filth on their clothing and persons. Tents, blankets and equipage in general became infected, and when the division moved to Knoxville it carried with it innumerable cultures of the Typhoid bacillus" (page 14).

In connexion with the state of the camp here described, it is stated as regards an outbreak in the 3rd Illinois Regiment that this corps occupied the site recently vacated by the 16th Infantry in which cases had occurred:—

> "It is possible that the 16th Infantry had infected the ground; * * * as an isolated instance, this fact can have no great significance; but we have found numerous similar instances, and we are strongly of opinion that only in case of the most urgent military necessity should any command be placed on a site recently vacated by another (page 12). This principle holds good even when the vacating regiment is not known to have suffered from any infectious disease. In many of the State encampments the regiments that responded to the second call were located on sites recently vacated by commands that had proceeded to the National camps." (In this sense there is certainly an "evil genius of locality.")

Several instances are then detailed as to the results in the outbreaks that ensued (page 186); the histories of the 12th, 14th, and 15th Minnesota Infantry Regiments are specially instructive both in regard to the danger of the re-occupation of infected sites, and to the transport and dissemination of infection by bodies of men in the movement from one camp to another (pp. 106, 107, &c.).

In close connexion with the subject of local infection are the influences which determine the special liability of troops in camp to contract the disease and to propagate it by infecting one another. Enteric Fever is disseminated by the transfer of the excreta of an infected individual to the alimentary canal (and, it may be added, probably to the lungs) of others :—

> "Typhoid Fever is more likely to become epidemic in camps than in civil life because of the greater difficulty of disposing of the excreta. * * * The whole question of prevention is largely one of the disposal of the excreta. Camp pollution was the greatest sanitary sin committed by the troops in 1898 (pages 178, 179). We may regard it as an axiom that wherever and whenever a large number of men assemble and allow their own excreta to accumulate about them, there and then Typhoid Fever will appear and will spread."

This is not to imply that the disease originates *de novo ;*

> "Typhoid Fever is so widely spread that in any large assembly of men collected from different parts of the country, there will be some already infected. From the dejecta of these the bacillus will grow and flourish in polluted places, and the disease will develop and spread" (page 46).

The Commissioners then proceed to discuss the conditions under which the conservancy of camps and the disposal of excreta is conducted ; the evidence they adduce is always and everywhere against the common trenching system and that of mere removal by pails in carts, and they recommend the use of tubs with thorough disinfection of *all* fæcal matter, or water-carriage where arrangements are available, or can be improvised. They give facts which go to show that "in a general way the number of cases of Typhoid Fever in different camps varied with these methods of disposal."* (Page 181.) They then deal with the evidence as to the most usual means of dissemination from polluted trenches, soil, etc., among these being personal contact of the clothing and person of individuals, flies and dust, their arguments being enforced by details as to the nature and extent of the outbreaks in different corps, which took the form in many cases of a series of "company epidemics," each one having its own individual characteristics, a subject to be referred to in the next chapter. A further important conclusion arrived at was that, "infected water was not an important factor in the spread of Typhoid Fever in the national camps in 1898" (pages 84, 182), though it is admitted that "there were probably local water-supplies that became specifically contaminated" (page 39). After a review

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* It has been stated that the chief factor in the decline of Enteric Fever in Bermuda, is the replacement of the dry-earth system of disposal by water-carriage to the sea. (A.M.D. 1900.)

of the evidence it appears clear that there were other factors in operation:—

> "which were incompatible with the assumption of a common simultaneous and continuously acting agency as the chief means of origin and propagation," (page 120)—a marked feature of the epidemiology which finds a striking analogy in India. "The sources of infection were, therefore, *plainly internal to the several camps*, whatever chances for outside infection there may have been;" * * * "although there may have been individual cases of infection outside of the camps, the chief source of the disease was to be found within" (page 145).

We have throughout laid sufficient stress upon that source, the human host and his excreta, and we have to recognize the fact that a man suffering from Enteric Fever may scatter the infection broadcast, but especially in places to which numbers of his comrades have constant access and where they must often come into direct contact with the virus (in latrines, etc.), before the disease is recognized, and thus the foci of infection are multiplied. With these conditions, we have those of close aggregation, inadequate space on the site and also overcrowding in the tents; the general arrangements for, and control of conservancy are far less adequate, as a rule, in camps; the circumstances also involve the less early and complete recognition of cases and the incomplete isolation of the sick. Finally, too frequently insufficient regard is paid to the choice of sites, especially in connexion with the constant re-occupation of places, the soil and water of which have been previously polluted with fæcal products.

One more of the conclusions of the Commissioners may be alluded to in connexion with the question of over-seas importation. They say:—

> "Even an ocean voyage does not relieve an infected command of its infection. This is shown in the study of the various commands that went to Cuba and Porto Rico. The regiments of the Fifth Army Corps that went from Tampa to Santiago in June were not widely infected before embarkation, and some of them were on board ship for 16 days, and yet all developed one or more cases either on the way or soon after reaching Cuba. In other corps more widely infected before leaving, the disease continued after their landing with but little, if any, abatement" (page 186).

The history of mining communities and expeditions affords striking corroborative evidence, and indeed, we are justified in stating the general proposition that wherever and whenever men congregate and live without adequate provision for the disposal of their excreta, Enteric Fever will there and then appear. Two or three of many instances may be cited which are the more instructive inasmuch as they demonstrate that under the conditions cited the results are the same at the depth of winter in the region of the Arctic circle, far remote from settled civilization, and in high summer in the tropic belt of the southern hemisphere. For the former we refer to the epidemic at Dawson City, on the Yukon, in January, 1899 ; the latter is illustrated in the experiences of the mining settlements along the reef at Johannesburg (Transvaal). An experienced observer reports that with the advance of summer, Enteric Fever and Dysentery invariably make their appearance among the miners on the Rand, and he refers to the ''latrine and pail system of conservancy'' as furnishing the means of infection. With these facts in view it is all the more suggestive that, as Thorne-Thorne has pointed out, the disease maintains its highest endemic prevalence in certain mining districts in the north of England where the conservancy arrangements are still most primitive. It is impossible to disregard the obvious indications herein provided for our instruction, in regard to the nature of the communities exposed, and the characteristic conditions under which they live.

New Zealand also furnishes evidence of outbreaks among the troops on service (Maori war), with the disappearance of the disease on their return to ordinary conditions of life, instances that would more properly come under the head of campaigns (see later), but that it is on record that Survey parties camped near the troops were also infected, the disease abating on the removal of the Camps.

Our own Army Medical Reports contain numerous references to camp outbreaks. As regards the prevalence of the disease in South Africa in 1880, the Principal Medical Officer observes that :—

> "Medical officers are pretty well agreed in assigning the cause to polluted water-supply at the various encampments on the line of march, and consider that it was not due to causes in the various stations in which it occurred. Cases of Enteric Fever and diseases of the bowels occurred, often largely, after a corps arrived at its destination, and were confined almost exclusively to fresh arrivals, ceasing after they had been a little while on the station. The appearance of the same disease in the Transvaal on its annexation in 1877, at the opposite season of the year, its cessation then and in the present instance (1880) when the movement of the troops ceased * * all point to the character of the disease as true Enteric and the influences of movements in camp."

Again in 1881 the P. M. O. (Cape) remarks :—

> 'Enteric Fever was prevalent in the latter part of the year in the Newcastle district, and was attributed to a polluted water-supply consequent on the

onset of the rains which washed impurities into the rivers. From the prolonged occupation of the district by Europeans and Natives, almost every available company ground had become contaminated, and the place was almost covered with latrines." He adds that "Ladysmith, as in 1879, proved a focus for the dissemination of the disease among corps marching through or stationed there for a time; this cannot be wondered at, for the practice of making a stream serve the double purpose of sewer and source of drinking water exists here."

Almost identical remarks appear in the Report for 1882, concerning the outbreak which occurred amongst troops in "camp in Natal in the hot season," and the P. M. O. ascribes it to the effect of heavy rainfall in washing impurities into the rivers and streams.

Turning to Indian experience, we shall confine the illustrations to two, taking what is probably the first on record, and then one of quite recent date. In the A. M. D. Report of 1871 there is an account of the outbreak in the 63rd Regiment, which occurred in the previous year on the march to Hazaribagh, and which was attributed to infection acquired in a filthy camp site just vacated by another regiment. For the later instance the Report for 1900 may be cited:—

"The Black Watch marched from Umballa to Sabathu towards the end of March 1897, and within three weeks of their arrival, 16 cases of Enteric Fever had occurred at Sabathu, the station having been previously free from the disease. Two companies, which marched with the regiment but went on farther to Jutogh, developed Enteric immediately on arrival there. The Royal West Surrey Regiment which marched the same road one day in advance of the Black Watch, developed Enteric immediately on arrival at Dagshai. The same occurred to the Bedfordshire regiment, which marched by the same route to Solon some days after the Black Watch. The one condition common to all these different bodies of men is the fact that they all marched along the same route at very much the same period, and the conclusion seems inevitable that the seeds of the disease were picked up *en route*. The water at some of the camps on the march was reported to be exceedingly bad." (A. M. D. Report, 1900, page 435.)

It must be remembered that in these cases the distances traversed and the time occupied in transit, were not sufficiently great as to permit of extensive outbreaks in camp during the marching period, and we have to look to the subsequent development and spread of the disease in the stations of destination for some measure of the evil involved in camp infection. As to this we have already given instances from the record of the Hill stations (see cases of Chakrata and Ranikhet); the circumstances detailed showing that we must frequently look to an original source of the infection in the plains cantonment from which the troops issue. And with this it may be noted that the contraction of infection cannot be attributed to the mere fact of removal from what is euphemistically called the "sanitary oasis" of the cantonment into the "desert of filth" beyond. We find a record of an unpremeditated experiment made during the successive hot seasons (the Enteric seasons) of ten years 1863 to 1872, when large parties of men were deputed from the plains to the duty of road-making in the Hills; the average strength exposed during six months of the years in question was 7,576, and the total number of deaths from "fevers" (Enteric not being then recognized in the returns) was 5, giving a ratio of only ·66 *per mille*, the total death-rate for the combined period being at the rate of only 2·24 *per mille*, at the unhealthiest seasons of the years. The "fever" rate would be 1·32 and the total death-rate 4·48 *per mille*, respectively, *per annum*. It is noted that "in no case have the men been selected as being robust and adapted for this labour" (*Vital Statistics of the Bengal Presidency*, 1874; pages 64, 65). This may also stand as additional evidence of the fact that Enteric Fever was actually, as well as nominally, far less prevalent among the troops, 30 years ago (see Chapter II).

We may regard the conditions under which the troops are transferred to the Hills and their temporary sojourn therein as affording, in many essential respects, a parallel to the characteristic features of camp life. From what has been said it will be clear that in the extent of the incidence of the disease on the troops in the Hill stations and in the circumstances attending its occurrence therein, we get some measure of the dangers attending the importation of the infection which is scarcely applicable to the cantonments in the Plains, partly because the course of events is to be less clearly discriminated in the latter, and partly because movements to the Hills take place just at the season of rising prevalence. Then we have, in the case of the Hills, the influence of the greater numbers of separate corps units represented in the aggregate strengths, and these units coming from various different places, so that the chances of the introduction of the disease are increased. The proportion of men at the most susceptible ages is, however, not so markedly higher in the case of the Hills, as to account for any great increase in the rates over those yielded by the men in the Plains, and there are very obvious advantages in the matter of climate. We may now compare the incidence of the disease on the troops located in Hill and Plains stations, respectively, during the last three decades.

Enteric Fever in Hills and Plains Stations, 1871-1900.

INDIA	RATIOS PER MILLE OF STRENGTH.					
	1871-80		1881-90		1891-1900	
	A.	D.	A.	D.	A.	D.
Hill Stations & Sanatoria ...	5·6	1·87	15.7	3·84	28·7	6·35
Plains Cantonments ...	5·0	2·27	12·8	3·81	23·2	6·48

The aggregate strength exposed to risk in the Hills was, in the first decade, 64,675, in the second, 77,835, and in the third, 117,662, which at once indicates a great increase in the traffic from and to the Plains during the period. The ratios for the Hills represent a recorded total of 4,964 cases and 1,165 deaths, which at once appeals to one's judgment as an unsatisfactory state of affairs as the record of health resorts. Further, the table shows clearly, that after the first decade, the period of the recognition of the disease, the Hills stand out with considerably higher admission rates, and that, therefore, the rise in these rates has been even greater than in those of the Plains. The first natural suggestion that presents itself is that this excessive prevalence may be due to the reception of Enteric convalescents in the Sanatoria, but this is negatived by the fact that the rates returned from these depôts are very much lower than those of the ordinary Hill stations ; *e.g.*, if we take the decade of greatest prevalence, 1891-1900, we find that the disease was recorded in the convalescent depôts to the extent of 16·3 and 5·10 *per mille* (admissions and deaths), whereas the rates for the ordinary Hill stations (cantonments) amounted to 32·7 and 6·75 respectively. Indeed, the more closely all the circumstances are examined the further we are led to conclude that we have to look mainly to importation of the infection and to its dissemination by the several agencies of contact, immediate or mediate, under the favouring influences of the aggregation of susceptible subjects, and that in the case of the Hills we merely see the operation of these factors in more clear and striking light. It has been pointed out (Chap. IV) that the men always join their regiments in the

Plains before proceeding to the Hills. We see the disease in the Hills increasing steadily during the course of the decades with its extension in the Plains areas from which the men are drawn, but at an even greater rate, and this increase coincides with the marked increase in the traffic to and from these areas which are so very distinct in their physical and climatological characteristics ; we have already had occasion to note the prime influence of the human host as demonstrated in the time of onset and the seasonal incidence of the disease in the Hills.

To the facts adduced concerning importation, we have to add that a study of the dates of the departure from the endemic centres, of arrival at the Hills and of the appearance of the first cases, goes to confirm the view set forth in a way that can scarcely be mistaken ; and if this evidence were less cogent, we know that calculations based on an arbitrary and definite period of incubation may very well mislead us as to the original source of infection. In a paper read before the Epidemiological Society, Skey Muir, in discussing the facts as regards Chakrata, gives the following details for the years 1899 and 1890 :—

Regiment.	Dates of arrival at Chakrata.	Dates of first cases of Enteric.
1889 4th King's Royal Rifles ...	March 29, 30.	April 9 to May 10.
1899 Details of above Corps ...	April 16.	April 16 to May 21.
1890 2nd Border Regiment ...	April 2, 3.	April 8 to May 4.
1890 Details of this Corps ...	April 14, 15.	April 14 to May 17.

And many other instances could be given of which the foregoing are typical. For example, in 1903, we find the following instances : Darjeeling : 2nd West Ridings, date of arrival, March 1st, date of first admission for Enteric fever, March 5th ; 2nd Argyll and Sutherland, date of arrival, March 13th, of first admission, March 30th. Ranikhet : 2nd Shropshire, date of arrival, March 8th, of first case, March 17th ; 5th Dragoons (detachment), arrived March 23rd, first case, April 4th ; 1st Bedfordshire (detachment) arrived March 23rd, first case, March 30th ; 1st Sussex, arrived March 23rd, first case, April 8th. Chaubattia : 1st Devonshire, arrived March 21st, first case, April 4th. Chakrata : 3rd Rifle Brigade, arrived

March 9th, first case, March 21st. Solon: 2nd Highlanders, arrived April 8th, first case, April 11th. Sabathu: 2nd Welsh, arrived April 9th, first case, April 14th. Jutogh: 2nd Welsh (detachment), arrived April 11th, first case, April 24th. Dalhousie: 1st Dorset, arrived April 7th, first case, April 8th. Kasauli: 2nd East Surrey, arrived March 17th, first case, March 18th. Mount Abu: 1st York and Lancaster (detachment) arrived April 1st, first case, April 2nd; 10th Hussars, arrived April 5th, first case, April 6th; and so on for practically all the stations for which the data are available. Such facts admit of but one interpretation.

The infection once introduced, most of the factors for its spread are abundantly present in the nature of the *personnel*, and in the conditions to which it is exposed and these have been set forth at sufficient length, but among them, the far closer aggregation of the men in smaller dormitories, the ventilation of which is too often neglected, must be emphasized. We would also here refer the reader to the statement given in Chap. IV (p. 152) showing the effect of the age and service constitution of the forces located in the Plains and Hills, respectively, on the prevalence of the disease.

A further deduction may doubtless be drawn from a similar comparison in the two periods of rise and decline comprised within the twelve years, 1891-1902; thus the following are the combined admission rates *per mille* of strengths.

Enteric Fever.

ALL INDIA.	1891-98	1899-1902	Decrease per cent.
Plains Stations ...	23·3	16·3	30%
Hills ...	30·9	19·1	38%

The second period of decline was, as has been frequently stated, that during which the army in India was so markedly affected by the suspension of the drafts and reliefs owing to the exigencies of the Boer War. We see then, that with a decline in the amount of susceptible *personnel* exposed there was a great decrease in the disease, and that this decrease affected the forces located both in the Plains and the Hills and those in the latter to the greater extent. These facts must assuredly be taken to confirm the intimate connexion between the occurrence of the disease in the two areas to which the other evidence points. And beyond this it can be easily shown that everywhere and always (allowing for the occasional vagaries of special epidemic outbreaks) the disease prevails in the Hills in strict accordance with its extent in the Plains stations from which the men are drawn; the Hill stations associated with the geographical groups in which Enteric Fever is always at its highest, invariably suffer the greatest incidence of the disease. It is difficult to account for these facts on any theory of the ubiquity of the virus in the environment outside cantonment limits, or beyond the immediate influence of the men themselves in camps along the marching routes. With the wax and wane of the known sources of infection and of the susceptible *personnel* at risk, we see the simultaneous rise and fall of the prevalence of the disease in two totally distinct areas, the sole connexion between them being the passage from one to the other of the host, the prime source and the chief vehicle of infection, while nothing in the period of decline could have affected the prevalence of the virus in the native environment beyond the influence of the troops. Further, the prevalence of Venereal diseases may be taken as some measure of the extent of the direct contact of the men with the native environment, a point to be discussed later; it is obvious that if the "natives be saturated with the disease" (A. M. D. Report, 1902), the danger of infection can nowhere be greater than in the bazaar brothels, where the men pass hours at a time, and where they are not only in direct contact with the natives, but indulge in drinks and food of all kinds provided on the spot. It is at least a suggestive fact that while the Enteric Fever rates are consistently highest in the Hills, the Venereal rates are there as consistently lowest, and this to a very marked extent; thus, during the period 1891-1902, the mean admission rate for all Venereal diseases in the Hills (groups XII a and XII b), amounted to 344 *per mille*, while that for the rest of India was 440. It must be remembered that the great majority of the men occupying the Hill stations are comprised within the age and service categories that, by the nature of things, are most liable to show an exceptionally heavy morbidity from Veneral affections, so that so far as this test avails, the evidence is again very decidedly against the prevalent hypothesis of indigenous native sources of infection.

In concluding this account of some of the special circumstances attending the prevalence of the disease in the Hills, as to which Chaps. III and IV should also be consulted, one or two supplementary remarks may be of interest and value. First, it may be said that the journey from the Plains involves, as a general rule, marches by road with rests each day in camp, for a period seldom exceeding one week, varying from two or three to eight days in different cases; this has a bearing on the very varying period of incubation. And, next, although it is customary to keep the men of a battalion or a detachment in the Hills for the whole period, April to October, it occasionally happens that some or all are returned to their headquarters in the Plains after the onset of the monsoon in July, or, at any rate before the usual time at the end of the season. Many of the Hill stations receive in addition convalescents (largely from Enteric Fever) and there are also detached convalescent depôts often in close contiguity to the ordinary Hill stations, the routes traversed being, for the most part, common to both ; convalescent cases are only retained for the period necessary to establish health. They come up individually, or in small batches, and after a stay of three or four months are sent back to make room for others in like case, and there is consequently a fairly steady procession from Plains to Hills and, reversely, throughout the season. Many of these men have suffered from Enteric Fever and all have had constant opportunities of contact with the infection among their fellows in both Plains and Hills, and in view of the lengthy period during which the bacillus may persist in, and be excreted from, the body of the host, we may at least see in these circumstances an indication of one mode of propagation of the disease and of the links, too often overlooked, between definite outbreaks in different places.

We pass on to consider the evidence derived from the records of campaigns, touching briefly on some of the more salient points, as it will be evident that we shall be merely dealing with an extension of the conditions which characterize life in camps in their influence on the origin and propagation of the disease. It should certainly be unnecessary in these days to emphasize the paramount importance to the efficiency of an army in the field, of minimising the extent of "preventible" disease. It is recorded that at the outset of the Russo-Japanese campaign, a high Japanese official when questioned as to the enormous odds to be encountered in face of the Russian resources in men, replied:—

"We are prepared to face two millions of Russians with our half million. In every war hitherto four men have died of disease for each one that fell by bullets or steel. That will be the position of Russia in this war. We propose to eliminate disease as a factor, and in this way we shall neutralize the superiority of Russian numbers and stand on a comparatively equal footing."

A month before the invasion of France by the German army in July 1870, every corps of the invading army was infected with Enteric Fever, and the infection was not confined to the Prussians but extended to every contingent from the federated States. The germs of the disease thus carried by the troops rapidly bore fruit, especially among those encamped for the sieges of Metz and Paris. Within less than two months from the declaration of war, the disease had extended so widely among certain divisions that more than 15 *per cent.* of the men of these commands were incapacitated. The invasion took place about the middle of July, and during the second half of that month the total number of cases in the army was 345, which is below the average in the preceding years of peace. In August, the cases increased perceptibly, and early in September a rapid extension of the disease brought the number up to 12,463 ; in October, the ordinary seasonal climax in Europe, there were 17,253 new cases, after which there was a slow decline till January, and this became more rapid through the succeeding months till the end of the war. During the autumn (1870) no regiment in the German army was free from the disease, the total number of cases recorded in the campaign (excluding officers) being 73,396, equal to 93 *per mille* or nearly one-tenth of the average strength of a force of over three-quarters of a million men.

The case of the troops concentrated in the camps on American soil during the short period of the Spanish war in 1898, was still worse. It is on official record that about 20 *per cent.* of the men in the national encampments, from April to September, developed Enteric Fever ; among 107,973 officers and men in 92 regiments, the records of which were carefully analysed, the number of cases was estimated at 20,738 of which 1,580 proved fatal. But the total force exposed was over 250,000 of all arms, and there can be little doubt that Enteric Fever must be reckoned to have prevailed in much the same proportion throughout the army. There were 4,136 deaths recorded during the year from all causes, including some 268 fatalities from wounds received in the field, so that, although the mortality in the camps, as a whole, has not been tabulated separately, it appears probable that fully three-fourths of this great loss of life must be attributed to Enteric Fever alone. The medical history of the Boer war has yet to be published, but we have the authority of the Commission appointed to enquire into the causation and prevention of Dysentery and its relation to Enteric Fever, for the statement that during the two years, from October 1899 to September 1901, no less than 24,294 cases and 973 deaths from the former disease, and 31,118 cases and 6,172 deaths from the latter were recorded, the loss from Enteric Fever alone "representing nearly an army corps." There is, further, ample evidence to show that this heavy record falls far short of the truth, on account of the non-recognition of the lighter and more aberrant forms of the disease.

The experience of the German Expeditionary Force recently operating in South Africa may also be cited. On March 13, 1904, the total strength of non-commissioned officers and men amounted to 476, and at the end of just six weeks, the loss by deaths from disease was equal to a rate of 17 *per mille*, that by invaliding from sickness to 130 *per mille*, and in addition to this there were no less than 44 men in hospital with Enteric Fever, a number which would represent over 100 *per mille* of the strength as reduced by fatal casualties in battle. All this within a month and a half in what is described as " in no way an unhealthy climate, and which has proved very suitable for colonization by Europeans."

It would be impossible to present a detailed summary of the epidemiology of Enteric Fever from the records of modern campaigns and expeditions within the limits of the space at command ; we can only allude briefly to some of the salient facts and, for the rest, refer the reader to the original documents. The course of events is very similar and characteristic, and in no other direction does history repeat itself with more significant iteration ; there is first, the concentration of the troops, followed by their rapid transport by sea to a tropical or subtropical climate, or the aggregation of corps units from different centres within a tropical area, and the transit along one or more main lines of communication across the frontier into alien territory. All the ordinary conditions of the soldier's life are suddenly changed by the exigencies of rapidity of movement, the restricted resources of transport and the makeshift compromises of camps. To unwonted fatigue, excitement and exposure are superadded sudden changes in the nature and amount of the diet, and a general *bouleversement* of the clock-work regularity of all the habits acquired in peace. The ordinary bread is often not available, and it can never fail to deteriorate in quality, while fresh meat is replaced by tinned provisions or experimental compromises in the shape of concentrated combinations, "sausage," pork and beans, and so forth. Reference is scarcely necessary to the disabilities incurred as regards the essential hygienic necessities of a pure water-supply and a complete conservancy; these have to give way, too frequently, to purely military exigencies. The results from the outset yield a monotonous record of digestive disturbances taking the forms of diarrhœa and dysentery, more or less severe, and often associated with "fever," and sooner or later true Enteric Fever emerges into recognition. The circumstances at the beginning of a campaign are altogether opposed to the discovery of the first cases, to the prompt and complete isolation of the sick and to the prevention of the transport and propagation of the infection, and the evil obtains a start which overhandicaps subsequent efforts at suppression: a few examples may be cited.

In the Galeaka-Gaika war (South Africa) the troops crossed the frontier in December 1877, the season being abnormally dry. Diarrhœa and Simple Continued Fever became prevalent, and in January we find Enteric Fever recorded and ascribed to drinking-water polluted by carcases. "In the latter part of this month some cases of Enteric Fever occurring among the Irregulars at Blanes' Farm were despatched to the Base hospital at King William's town, and shortly after, the disease appeared among the Regular troops quartered at this Station." The late onset of the rains early in March was rapidly followed by a great increase in the cases of diarrhœa and dysentery, with the usual sequel in outbreaks of Enteric which prevailed through April and May among all arms; "it appeared to make no difference whether the drinking water was taken from a spring or a river; no local cause could be discovered, "climatic" causes being invoked. From reports of three medical officers at different stations, it appears, in the first instance, to have been imported into the ranks from outside sources; see examples, that leave no doubt on this point, on page 255 of A. M. D. Report for 1878. Subsequently, we find Enteric Fever occurring in the Cape garrison ascribed to importation by men returning from the campaign (page 76 *ibid*).

The same remarks apply to the Zulu war in the following year, the operations commencing in January 1879. The season was again abnormally dry, and "fevers" accompanied by dysentery and diarrhœa, became very prevalent in February at the head-quarters at Helpmakaar and at Rorke's Drift. A force of over 1,000 men, Europeans and natives, were crowded together in camp and now exposed to rain and chills without tents. The soil is said to have been saturated with excreta, and there is the usual discussion as to the true nature of the fever, whether "bilious remittent" or "Enteric." The sickness led to the removal of part of the force to Utrecht and part to Dundee, and epidemics immediately broke out at both places ; a study of the dates leads to the conclusion recorded that "this clearly proves that the disease was imported by these regiments." The outbreak was first marked at Utrecht among the men who had arrived from Helpmakaar, and it subsequently spread to others in the same garrison ; the circumstances at Dundee are described in identical terms. It is further noted that "the prolonged occupation by troops of the 1st Division, of the same site tended in great measure to maintain the sickness." In contrast, the 2nd Division, which was in constant movement on the rolling uplands of the North, was comparatively free from sickness. The S. M. O. at Fort Pearson declared that the disease was imported from Thring's Post and Saccharine, many cases diagnosed elsewhere as "Remittent" and "Simple Continued Fevers" being found on admission to be true Enteric. Surgeon-Major Hodgson corroborates : "I conclude that Enteric Fever was originally brought from Durban" (where the British troops disembarked) "and was carried by the men to various stations where it broke out and was aggravated by the gathering of large numbers of men and cattle and the insanitary state accompanying such conditions." Instances are given of the disease being confined to certain corps, while others, camped with them, escaped. The sickness and mortality rates recorded during the campaign from "Fevers" among the British N.C.O. and men (strength 12,651), were equal to 220 and 14 *per mille* : those for the white Irregulars (strength 1,942) were 245 and 13, and those for the Black Auxiliaries (strength 5,436) were 16 and 1·4, respectively (A. M. D., 1879).

In the Afghan campaign (1878-79), it is noted that cases of Enteric Fever occurred at almost all the posts occupied by British troops, from the Indian frontier to Kabul and Kandahar. Some of these posts had, in all probability, never been occupied before, some are remote from human habitations and traffic, and many of the cases were quite isolated, no general outbreak ensuing. It is possible that here and there the water-supply was specifically contaminated, though, as a rule, the circumstances rendered this unlikely in the physical nature of the country and of the water sources; the soil of a more or less barren and mountainous and sparsely-inhabited area such as that of the North-West Frontier and the region beyond was scarcely liable to pollution, save as it became so by occupation by the troops. And we have indubitable proof that Enteric Fever was widely prevalent among the troops in cantonments before their departure from India, and on the line of march to the scene of operations. These commenced in November, 1878, and so far as the record indicates the first *fatal* case was reported on the 9th of that month, which shows how close a connexion, in time, can be traced between the disease in the field and that in the forces before leaving India (A. M. D., 1879, page 247). Nothing like a connected account of the course of the disease, nor even of isolated outbreaks, is to be found in the official reports, and what is here given is pieced together from isolated references; it is evident that no adequate conception of the etiological factors in operation was grasped by those with opportunities for surveying and analysing the many scattered sources of evidence; the broad indications are nevertheless perfectly clear.

The case as regards the Egyptian campaign of 1882 is somewhat more detailed and connected. We find distinct evidence that some of the regiments sent direct from England and withdrawn from Mediterranean garrisons were already infected before arrival at Alexandria and Ismailia, for cases were recognized soon after disembarkation, and this apart from the prevalence of diarrhœa, which was noted "in some corps almost at once after landing; and this continued throughout the campaign, being often present among men who remained at their duty and never felt ill; but some of these cases were, no doubt, in reality mild, aborted or ambulant forms of Enteric Fever." (*A.M.D.* 1881, page 279).

The main body arrived in transports at the base, Ismailia, on August 20th; an official report states that:—

"almost from the commencement—from August 24th—cases of Enteric occurred; and their number slowly increased at Ismailia from August 28th up to September 29th (21 cases in all); on August 29th I saw some cases of Enteric Fever on board the "Euphrates" and I learnt that a man from H. M. S. "Thalia" had *died* of the disease on 25th August on the former vessel." (Page 280).

From Ismailia, the disease accompanied the troops until the army went into camp outside Cairo between September 20th and the end of the month :—

> "The canal was the only source of water on the Ismailia-Cairo line * * * and this water may have been fouled by the *débris* of camps blown into it, or possibly, even by the excreta of patients in course of transit down the canal. Still I do not think that all the Enteric Fever that occurred can be attributed to the use of this water." (Page 281.)

The Indian Contingent and the Manchester regiment, which garrisoned Ismailia and used the same water at the lowest point of the area occupied were, it is noted, practically free from the disease, facts that hold good also for the Seaforth Highlanders, at the same place. As regards the camps at Cairo, a case was reported on September 30th and :—

> "admissions began on October 3rd ; the disease gradually increased, reaching its greatest prevalence late in October and in November," when the force was dispersed. "Some of the regiments operating on the Ismailia-Cairo line had come from Alexandria and Ramleh and were already infected, and others from the same places went to Cairo." It is noted that corps like the "Household Cavalry and Dragoons, who were in the desert during the whole of the campaign, appear to have suffered comparatively little from Enteric Fever, though they had very hard work, much exposure, bad water and insanitary camps."

Other cavalry regiments, in all respects similarly circumstanced, but who remained long in camp at Cairo, suffered greatly, but at the *end* of the period of occupation, *viz.* in November and December. It is only fair to add that the ground round Cairo utilized for camp sites, as well as the Egyptian barracks, were reported as showing evidence of either actual or possible fæcal pollution before occupation ; at the same time, we have the evidence of the presence of infection among the troops before arrival, and the references to the difficulties of establishing and securing a decent system of conservancy for the troops in camp are numerous and suggestive, occurring as they do in the Sanitary Officer's diary as late as the middle of October (page 285). The other considerable outbreak occurred in the camp at Ramleh near Alexandria. "The Shropshire regiment landed from England on August 21st, and some of the early cases came from this corps," the first at the camp being recognized on September 1st. Other regiments which suffered heavily were the South Staffords and the Berkshires ; they both moved into camp at the end of August. The former had come from Malta where Enteric Fever was prevalent, the latter from Gibraltar, where it had arrived from England in March of the same year, and "had suffered severely from fever." The outbreak was attributed to polluted well-water, but it is noticeable that other corps units, encamped about four miles from Ramleh, did not furnish cases of the disease, though they also came from Malta.

In all essential respects the foregoing account might stand for the record of the French army of occupation in Tunis in 1881 (*Arch. de méd. et pharm. militaires*, 1883). In round numbers, 4,200 men out of a strength of 20,000 men were attacked by Enteric Fever; all the columns on the march were more or less affected and almost every occupied post, whatever its geographical or topographical position, was invaded. Here, again, there is evidence of importation of the infection; the regiments in which the disease was present in France before embarking yielded the early cases in Tunis, and then when brigaded with other troops, the disease spread to the latter, who suffered severely. The brigade was then broken up; the component corps went to different places all of which became infected in greater or less degree. Two other brigades never within 50 leagues of the one in question, did not furnish cases until some 40 days after landing in the country; this circumstance gave rise to the suggestion of the alternatives of "no contagion" (? no importation) "or prolonged incubation", but we know better now how to interpret the facts regarding the latter. The condition of the camping sites is described in terms that make it easy to understand the spread of infection when once introduced. Regiments from the temperate region of Northern France suffered more severely than others, and far more than the Algerian troops; the immunity of the Zouaves and Tirailleurs is attributed to acclimatization and to the "privilege of race." The men were overcrowded in tents, and the arrangements for the treatment and isolation of the sick were defective. The corps of Engineers, the Transport arms and Cavalry suffered most, as these, besides being most exposed to the ardours of the campaign, were specially subject to the influences of over-crowded sites polluted with the excreta of animals.

Again, in the Oran expedition of 1885, the French commands were encamped in desert stations, never previously occupied, and in these Enteric Fever not only broke out but prevailed in epidemic force.

In Egypt, in 1885, our troops were operating along the Nile and in the Soudan, and there was also a combined European and Indian Contingent in the field on the Red Sea littoral with the base at Suakim. Hamilton reports in regard to the latter, that a splendid body of picked men was landed at Suakim, all sick having been previously left at Suez. Within two months, bowel complaints including Enteric Fever prevailed in a most virulent form, there being many cases from every corps, and soon the hospitals and hospital ships were overcrowded in spite of their depletion to the extent of 1,000 cases sent Home. He refers to the great heat, but remarks that the troops were encamped on the virgin soil of the coral coast and sandy desert; the "dry earth" system of conservancy was "nominally" practised, but the trenches were frequently placed to windward of the camps and there was a notable neglect of all proper precautions in the British lines, the filth trenches being often left uncovered for days, while the sea-breezes transported the powdered excrement in all directions. "Given a case or two of Enteric Fever, and the source of the outbreak is clear." Farther inland the troops were huddled together in "Zareebas" with foul filth-trenches just outside, with the result that diarrhœa first broke out to be followed rapidly by Enteric Fever; but he is careful to note that the farther such camps were removed from the base at Suakim, the healthier they were, owing to the fact that they were occupied for a shorter time. The drinking-water was obtained by condensation of supplies from sources running into the harbour, but the process was faulty and unreliable;* the bread and meat were probably contaminated at every stage of preparation, by the use of polluted water or by contact with flies, which constituted a veritable plague. The native Indian troops and followers, as well as the Arabs, suffered from dysentery and malarial fevers, but the European members of the Indian Contingent were free from any symptoms of Dysentery or Enteric Fever, although the soil in their neighbourhood was impregnated with excrement and rendered damp by the flow of the tide; it is, however, noted that the conservancy of the Indian Camps was in every way completer and better carried out than in the case of the troops from England. (A.M.D. 1884 and 1885). Reference has already been made to the probable fact of the importation of the infection by the men of the Shropshire regiment, and the foregoing statement affords suggestive evidence of the same for other corps.

* The Principal Medical Officer, on the other hand, says "the water-supply appears to have been particularly free from suspicion."

The records of the Expedition to the Soudan during the same period afford very similar testimony. It is true that we do not get anything in the shape of a connected account of the course of events in the official Reports, but even here there are several references to the transport of the disease from one post to another, from the field to the stations in lower Egypt and in the reverse direction, *e.g.* from Assuan to Korosko, and from Suakim to Suez by convalescents. But in an account of his experiences at Korosko given by Caldwell in his recent prize Essay ("*The prevention of disease in Armies in the Field*") we get more light on the subject. Korosko was then a small Arab settlement on the bank of the Nile, with a small and scattered population, the soil being sandy, arid and devoid of vegetation. The author had frequent opportunities of acquainting himself with the character and extent of the diseases to which the natives are liable, as he treated them professionally and paid frequent visits to their homes; he never saw a case resembling Enteric Fever among the fellaheen, nor could he glean any facts pointing to the prevalence of the disease among them. The British troops encamped here were at first quite free from Enteric Fever, the most scrupulous care being given to all sanitary measures; a little later the men (strength 700) were accommodated in mud huts instead of tents, and bucket latrines were substituted for trenches, the night-soil being buried at a distance; the sanitary state of the Camp was good and the water carefully boiled. Meanwhile in the old standing camps at Assuan and Wady Halfa Enteric Fever was steadily increasing, and now in spite of all efforts the disease appeared at Korosko. The official Report (1885) already alluded to affords the explanation;

> "At Korosko there were 16 cases and 6 deaths; these occurred chiefly in the Yorkshire regiment soon after they arrived from Assuan, where the disease had been prevalent; prior to the arrival of this corps the health of Korosko had been remarkably good" (p. 143.)

Caldwell gives statistical evidence of the influence of prolonged occupation of camp sites on the rise and spread of the disease, and with prolonged occupation must be associated the facts establishing importation of the infection from place to place; he concludes that soil pollution (excremental) is the chief factor in inducing propagation after importation.

The Chitral expedition next furnishes some instructive evidence. The troops of the 1st brigade, 1,601 officers and men, left Peshawar on 29th March 1895, and it is said that there were no cases of Enteric Fever in the station hospital at the time, but this does not exclude the possibility of the infection among the men. In the first place, the records show that two cases were under treatment in the hospital in February (and subsequently five cases in May), and then the first "undoubted case" was recognized in the Force on 29th April, but this had been preceded by several other cases, the diagnosis of which had been doubtful and which had been transferred to base hospitals, and which later proved to be Enteric Fever. After the battles of Malakand and Khar on April 3rd and 4th, these troops were encamped at the latter place in the Swat valley, 2,000 feet above sea-level. The health was at first good, but with the increasing heat, the men, who were overcrowded in small single-fly tents, began to suffer from "malarial fever", and Enteric Fever soon made its appearance. About the middle of May, the regiments comprised in this brigade, marched from Khar to the top of the Larum Kotal, 6,500 feet above sea-level; one, the King's Royal Rifles, arriving on the 28th followed closely by the other, the Bedfordshire, on June 1st; during the month, *i.e.*, while at Khar and on the march, altogether 18 cases and 10 deaths from the disease had been recorded. When the Bedfordshires arrived on the Larum they at once settled down on the camp site which had been occupied by the K.R. Rifles for four days, the latter corps being now moved away along the ridge for two miles. "Throughout June, July and August the epidemic continued in both corps, being more severe among the men of the Bedfordshire regiment" which had 128 cases with 28 deaths in all up to the date of leaving Larum for India (August 24th). "On September 4th a third regiment, the Buffs, arrived at Larum; they encamped on the ground which had been vacated by the Bedfordshires" (and previously also occupied by the first arrivals, the King's Royal Rifles); "Enteric Fever attacked them almost immediately and they had 11 cases before they were sent back to India on September 14th". Here, then, we have evidence of the infection being carried by the troops into the field and of its adhesion to the corps in their progress, with the striking fact that three regiments which were encamped in close succession on the same site were all rapidly subject to more or less severe outbreaks on that site :—

"The Rifles brought it with them from Khar, as did the Bedfordshires in the first case, while the Buffs appear to have contracted the disease on the ground. The water-supply appeared to be beyond suspicion, as it came from a spring which bubbled out of the rock near the top of the Pass; the ground above not being contaminated in any way. The milk obtained mostly from goats was always boiled before use. There was over-crowding in the small tents and many cases arose from the close contact of the men, in the initial stages of the disease, with their comrades. It is remarkable that no case of Enteric Fever occurred amongst the officers at Larum though they had the same water and milk supply as their men." (*A. M. D.* 1895, *pages* 391, 392.)

It is not necessary to devote space to the discussion of the course of events in the Tirah campaign (1897-98); the general lessons it teaches follow the familiar lines, but the details in the official Reports are not sufficiently exact nor connected, to merit quotation.

Nor are we yet in a position to analyse the evidence and so to appraise the relative influence of the various factors in operation during the Boer war (1899-1901)—The medical history of the campaign is still unwritten, and it is said that there was no

"machinery and staff to focus, localise and ascertain the causes at work in particular camps. Neither the weekly returns nor the admission and discharge books contain any definite information on the question of the distribution of the sick in the various camps; * * in war time when hospitals receive sick from different regiments, when regiments are more or less broken up performing duties at different camps, and when large numbers of troops are collected in many different camps in and around a town, an accurate record of the zymotic sickness in each camp becomes a matter of vital importance." (*Report of Dysentery Commission.*)

In the accounts already published stress is laid on the prevalence of the disease both among the natives of the country and the Boer forces, whose total neglect of sanitary precautions and whose military positions in regard to the British troops could scarcely fail to provide abundant sources of infection for the latter, by the pollution of the water-supplies common to both and by the fouling of the camp sites which were subsequently occupied by our men in their advance. It is consequently impossible to mark down from the data at present available, the origin of the first cases from which the disease spread throughout the army; "it is evident that both Dysentery and Enteric Fever were prevalent in the Modder River command before any portion of it started for the relief of Kimberley or in pursuit of Cronje and that the portion of Lord Roberts' army concentrated at Modder River, incurred considerable risk of becoming infected." It is, however, noted that all the usual conditions for the spread of the disease were abundantly present in the British camps. The nature of the soil was unfavourable to the trenching of excreta ; during "rain and floods the trenches drained into the rivers, and during dust-storms, paper, etc., was lifted from the trenches and scattered about the camp." The physical conditions of the site also "afforded opportunities for defilement of the ground without detection." And so it is recorded that "both the Boer and British forces were infected when they left the Modder River and started for Paardeberg," and many cases occurring at the latter place among the men of both armies were traced to previous infection on the Modder. Thenceforth we have a history of infected bodies of men in constant movement transporting the disease in every direction, dropping cases on the way and arriving at various places to be subject to more or less wide-spread outbreaks during their temporary sojourn.

> "The large number of Boer prisoners who afterwards developed Enteric at, and on the way to, Cape Town undoubtedly contracted the sickness at Paardeberg, just as numbers of the British force fell ill on their march to Bloemfontein and were sent to hospitals at Kimberley and the Orange River. * * Seventeen days after their arrival at Bloemfontein 250 cases of Enteric Fever and 759 cases of Simple Continued Fever had been admitted into the hospitals there."

That is to say, within 30 days after the troops left Paardeberg, and it is stated that numbers first came under treatment only during the second week of active symptoms. Subsequently, during a period of 7 weeks, there were 4,280 cases of Enteric and Simple Continued Fevers admitted at Bloemfontein, and thus 10 *per cent* of the force there was disabled. "That which occurred at Modder River, Paardeberg and Bloemfontein, occurred in other places in a minor degree, the causes being similar," and notably at Kronstadt, Pretoria and among the British prisoners at Waterval who carried the disease with them from Pretoria. With importation of the infection, all the local conditions in regard to polluted water-supplies and neglect of conservancy, together with privation, fatigue, exposure and aggregation, were calculated to promote propagation. One cannot evade the conclusion that a predominant rôle was played by specifically polluted water, but generally as the most direct means of conveyance of excremental matter which was distributed everywhere in and around the camp sites ; where infection was so abundant and in such close proximity to susceptible subjects it was a question merely as to the means by which it could most readily obtain access to the body, and there is little doubt that water often afforded these means, and, thus it may be contended that drinking-water played a part which rarely falls to it under ordinary circumstances in peace. At the same time the conditions were such, in the absence of reliable data, as to preclude a more precise differentiation of all the factors at work,—direct contact, air-borne polluted dust and flies, etc. That these must be taken into account is, however, very evident from the more or less definite statements which constantly recur, and notably in regard to the epidemic at Ladysmith, where strict precautions appear to have been taken as regards the effective filtration of the water which was derived from a source "free from liability to contamination". And here the great number of the sick and the necessity of keeping them out of the line of fire, together with the inadequacy of proper hospital accommodation, caused overcrowding and the utilization of any available shelters. The paucity of sick attendants was another serious disability, and

> "soldiers who had been in hospital but had recovered had to be kept in camp to nurse their comrades." Colonel Exham is of opinion that "the spread of the disease (at Ladysmith) was largely through the agency of flies, which were so numerous that it was not possible to keep them off one's food in eating. The enormous swarms of flies were doubtless due to the number of animals present with the force, and to the accumulation of litter in the camps."

Caldwell gives some interesting details from his personal experiences with the Natal Relief column; the different units arrived at Estcourt at irregular intervals and were encamped there for two weeks, the weather being rainy and inclement and the water-supply derived from the turbid rain-swollen river. The health of the men is said to have been good at this stage, though diarrhœa was somewhat prevalent and there was at least one case of Enteric Fever recognized; the camp sites had not been previously occupied by troops for any considerable time. The force marched on January 9th, exposed to trying conditions of weather, rain and cold, with defective clothing and food, the men sleeping in their wet clothing at every halt, and drinking indifferently from pools and streams passed *en route*. The Tugela was reached at the end of the month and the men went into camp on or near ground previously occupied by our troops, and which is described as saturated with filth. Up till this point diarrhœa and dysentery only had appeared (beyond the one case of Enteric at Estcourt), but now some five or six weeks after the muster, there was a marked increase of all bowel complaints and fevers, Enteric Fever showing itself in unmistakeable form. In the author's experience a similar course of events was constantly observed, and he was forced to conclude that the infection was definitely located in camp sites fouled by excreta, and that although the water-supply was undoubtedly occasionally polluted, there was cogent evidence against the exclusive rôle of water in conveying the infection. He instances the occurrence of the disease in block-houses after long occupation, wherein the men were often huddled together in dangerous contact, and where tea and coffee were frequently the only forms in which water was consumed. As regards the Boer prisoners transported to St. Helena, Caldwell affirms that endemic sources of infection could be certainly excluded; during five years' residence in the island he saw only two cases of Enteric Fever, and these both occurred in Jamestown, and there is reason to believe that the disease is unknown in the rural districts, in the highest and healthiest sites of which the Boers were camped. Deadwood camp was considered to be an ideal sanitarium, and yet here the prisoners suffered severely. Lieutenant-Colonel Morse (Principal Medical Officer) says that Enteric Fever was imported by each batch of prisoners, and that the infection was spread through the agency of flies and dust.

When it is considered that the reporting officer on the spot is in most cases deprived of the power of tracing the origin of first infections, by the complications introduced by the movements and the combination of different units, by the absence of records and by the engrossing calls upon his energies in dealing with an outbreak, it is surely scarcely a subject for wonder that clearer ideas of the etiology of the disease have been obscured by conventional prejudices, on which, however, recent experiences in America and South Africa have exerted a dissipating force. Observers have been compelled to revise their conclusions, and we see the results in a widening of the point of view, the first effects of which may well be to produce some haziness of outline in the facts observed ; but this is surely merely incidental to a closer approach to the truth they reveal.

The view for which we here contend is supported by the results recorded in the peace establishment when joined by the troops returning from field service. Numerous references could be cited from the official Reports, *e.g.*, those of the Sanitary Commissioner (India) ;

> "The transfers from regiments returning from the Isazai Expedition caused the seasonal incidence of the disease to be diverted from its normal course, to a later period of the year, *viz.*, to October and November in Upper India" (1892, page 34) ; "In a number of the cases admitted in Punjab stations in 1895, the disease had been contracted with the Chitral Force (1895, page 31). * * * At Cherat, a large number of cases come from a barrack close to, and from tents pitched on, the site of the Base hospital for the Chitral Force. The soil was, there was no doubt, saturated with filth (1897, page 40). * * * The evil effect upon individuals and upon regiments employed on active service on or beyond the frontier (Tirah) was observed in several stations (1898, page 35). * * * The high admission rate from Enteric Fever at Rawal Pindi was in great part the effect of field service. During the three months in which the troops were returning by units, no less than 73 cases occurred in Rawal Pindi" (1898, page 43).

Among the stations standing highest in the Enteric list in 1897-98, fourteen were associated more or less directly with the campaign influences, by the fact that part of their garrisons had been sent on, and had returned from, field service.

Although not obviously germane to the subject of Camp and Campaign influence, we may conclude this account with a note on the occurrence of Enteric Fever in the military Prisons, if only because the conditions of incarceration are in nearly all respects the reverse of those we have been considering. There were twelve of these institutions in use in India, during the quinquennium 1900-04, and they are nearly all attached to the largest cantonments, *viz.*, Quetta, Allahabad, Lucknow, Agra, Bangalore, Secunderabad, Fort St. George, Mian Mir, Saugor, Dagshai, Peshawar and Poona. Excluding the last-named, where an exceptional outbreak (4 cases) occurred in the Prison in 1903, the total strength exposed during the five years in the eleven Prisons was 771, and among these there were in all 8 cases and 2 deaths, which give ratios of 9·8 and 2·5 *per mille*, whereas the incidence on the troops in the attached cantonments (strength 72,796) was at the rate of 21·1 and 4·5 *per mille*. This is at least suggestive when regard is paid to the smallness and fluctuating nature of the individual jail populations, to the probability of the more intimate contact of the prisoners with the Native environment before incarceration than is the case with less adventurous and orderly men, and to the risks of importation into the prisons from cantonments. Without pressing its significance too far, it certainly tends to support the contention maintained as to the paramount influence of direct contact among the modes of infection.

CHAPTER VI.

EPIDEMIOLOGY (III).

Arms and Corps Units. Officers, Women and Children.

IN a most valuable and interesting Essay on "*Enteric Fever amongst the British Troops in India,*" which appears as an Appendix to the A.M.D. Report for 1900, Major McCulloch, R.A.M.C., gives a table showing the incidence of the disease on the different arms of the service from 1895 to 1900, the main points of which are summarised in the following statements :

TABLE XXXVIII.

Enteric Fever in the different Arms of the Service, 1895-1900.

RATIOS PER 1,000 OF STRENGTH.

ARMS.	1895.		1896.		1897.		1898.		1899.		1900.		Total 6 years.	
	A.	D.	A.	D.	A.	D.	A.	D.	A.	D.	A.	D.	A.	D.
CAVALRY (Agg. str. 28,008)	27·6	7·35	26·5	6·29	54·3	15·42	54·2	11·95	45·6	11·99	36·1	9·22	40·6	10·35
ARTILLERY (Agg. str. 69,461)	22·4	5·09	25·2	6.0	31·1	8·43	31·3	9·48	23·6	6·59	12·8	3·79	24·6	6·61
INFANTRY (Agg. str. 276,057)	23·6	5·85	27·2	6·83	32·0	8·62	37·7	10·85	19·1	4·53	17·0	5·10	26·0	6·93

In the author's table the figures for the Artillery are given separately for the mounted and dismounted branches, and when the combined results for the whole period are summarised, the incidence is as follows :—(see next page.)

TABLE XXXIX.

ARMS.	1895-1900 Ratios per 1,000 of strength.	
	Admissions.	Deaths.
CAVALRY	40·6	10·35
ARTILLERY, Mounted { Heavy Batteries ...	28·5	6·28
ARTILLERY, Mounted { Horse, Field, and Mountain Batteries	27 8	7·55
Do Dismounted, Garrison ..	15·4	4·01
INFANTRY	26·0	6·93

In order to bring the record up to date we may supplement the first table by a statement of the results for the last three years, those for 1901 not being available :—

TABLE XL.

ARMS.	1902.		1903.		1904.		Combined period 1902-1904.	
	Ad.	D.	Ad.	D.	Ad.	D.	Ad.	D.
CAVALRY ...	34·0	7·56	46·4	8·34	45·4	9·04	43·6	8·47
ARTILLERY ..	22·1	5·83	17·0	4·45	25 2	5·00	21·5	5·09
INFANTRY .	14·1	3·59	17·7	3·66	16·8	2·91	16·3	3·38
INDIA ..	16·6	4·26	19·7	4·15	19·9	3·65	18·8	4·01

The latest figures thus merely serve to emphasize the remarkable contrasts in the incidence on the different Arms, which are exhibited during the years of the maximum prevalence of the disease. The most striking features are the position of the Cavalry in relation to that of the Infantry, the mounted branches of the Artillery occupying an intermediate place, but still very near that of the Infantry, while the Garrison Artillery shows to great advantage. The Artillery as a whole is served by men of the best physique available, and the proportion of those at the most susceptible ages (as regards Enteric Fever) is lower than in the Cavalry or Infantry, thus :

TABLE XLI.

Ages of the Non-Commissioned Officers and Men of the different Arms serving in India, 1895-1902.

ARMS.	PROPORTIONS PER CENT OF TOTAL STRENGTH.		
	Under 25 years age.	25-30 years.	Over 30 years.
INFANTRY	59	31	10
CAVALRY	56	32	12
ARTILLERY	52	36	12
GARRISON ARTILLERY (1903 only)	37	43	20

(Extracted from the General Annual Reports of the British Army.)

It can scarcely be doubted, in view of the facts previously adduced, that the age-constitution of the different Arms has some influence in determining the relative incidence of the disease. We may fairly assume that it goes far to account for the remarkable position of the Garrison Artillery in the Enteric list ; the men of this arm live under conditions closely approximating to those affecting the Infantry, but they have a distinct advantage in regard to age, and beyond this they are aggregated in much smaller corporate bodies and are probably less subject to movements and to fluctuations of the *personnel*, which, as has been seen, are considerations of great weight. Turning next to the most interesting problem of the contrast in the liability of the Cavalry and Infantry, we have to note, first, that the same phenomenon is exhibited elsewhere in foreign armies. In the French army during the operations in Tunis in 1881, the mortality from Enteric Fever followed the same order, that of the Cavalry and Transport Corps exceeding that of the Infantry in a notable degree, and the same results are recorded by Munson for the United States army.

"For the period 1867-1883 inclusive the admission-rates per 1,000 of strength were as follows: Cavalry, 19 ; Infantry, 4·6 ; Artillery, 2·5 ; * * * the death-rate in the Cavalry was more than three times greater than that of either of the other arms. This great difference was largely due to active field service against the Indians required of mounted troops. In 1890-96, the admission rates per 1,000 were 8·03 for the Cavalry, 5·74 for the Infantry and 4·74 for the Artillery. He adds that "in time of peace the Medical Department is affected less than any of the above arms of the service; during the war with Spain it suffered more than twice as much as any of them"—

which is significant of the influence of contact in the propagation of infection. Major McCulloch in discussing the probable causes of the excessive incidence on the mounted arms points to the fact of their "daily contact with animals, * * which, in India are horses, mules, bullocks and elephants." He adds that the same purity of water-supply for animals is not insisted on as in the case in the drinking-supplies for human beings, and he suggests the possibility of Enteric bacilli passing through the bodies of animals in an active condition, and so infecting stable litter, the ground of stables, horse and cattle lines, etc. "The men are more in the way of temptation to drink unsterilized water than is the case of the infantry soldier." To these considerations may be added the notorious fact that men are everywhere accustomed to urinate in stables and cattle lines, and so scatter the infection where they work with great strain on the respiratory function in grooming their horses; hands, mouths and clothes are specially liable to pollution in the dusty atmosphere under these conditions; and, further, we may not overlook the favourable breeding nidus supplied by dung and stable litter for flies, which may easily carry the infection which must be distributed in the stables by early cases and, doubtless, by convalescents.* But in addition to these considerations, we are justified by the evidence in looking for the explanation in some special conditions affecting the human host.

Now the age factor can scarcely be invoked, as the statement furnished shows that the Cavalry in India includes a smaller proportion of men at the most susceptible ages. The difference is certainly not great, but the fact affords one more indication that age-constitution is only one, and not the most important, factor in the general problem of liability. The case of the Cavalry, indeed, serves but to confirm the conclusions already set forth on this aspect of the subject, when the facts are grasped. In the first place, Cavalry regiments are nearly all located in what we have designated the endemic area, and the incidence of the disease as calculated on the rates is contrasted with that falling on the Infantry in all parts of India,

* The training in the riding-school is another special feature to be noted; clouds of dust are raised which the men must inhale under the conditions involving increased respiratory efforts.

including the non-endemic areas, which must, to some extent, tend to lower the rates on the latter arm as a whole. Again, Cavalry corps always occupy the same stations where the lines are adapted for them (stables, etc.); the nine British Cavalry cantonments are all occupied for a period of five years, at the end of which the regiments are transferred to another station previously occupied, and just vacated, by Cavalry; whereas the Infantry units are transferred to various stations it may be beyond the endemic area or to barracks and lines not previously associated with excessive prevalence of the disease. The term of occupation of any one station for Infantry is one of two to four years only, a fact which has a pertinent bearing on the influence exercised by local ("place") infection. In a word, whereas in the Cavalry, infection is most abundant and can be rarely absent, the corps occupy infected sites for longer periods, and when they move, they pass on to similarly infected sites for a further prolonged term of exposure, while the Infantry has more frequent chances of quitting an infected site. Furthermore a Cavalry regiment is as a rule restricted to a nine years' term of service in India, while for the Infantry it is generally extended to 16 years, there is therefore the influence of more frequently renewed exposure of the former to the risks connoted by the first touch with the environment which has been shown to exercise a more powerful influence for evil than a low age constitution. The Infantry must secure advantages in the course of a longer experience of the environment, and with it, of the disease, which are denied to the Cavalry, and this not only as regards India itself, but elsewhere, as there are no Cavalry posts in the Mediterranean to eliminate the most susceptible subjects on the way to this country. A far larger proportion of the Cavalry corps come direct from Great Britain* and disembark with larger actual and relative numbers of highly susceptible men (fewer being eliminated by previous attacks or rendered more resistant by acclimatization elsewhere), and the circumstances attending the voyage enhance the risks of the importation of infection, not only by the embarkation of actively or potentially infected individuals at the Home port, but by association with Infantry drafts or reliefs picked up *en route*, and by visits paid on shore at the various ports of call. It is to be

* During the whole period since 1891, 14 Cavalry Regiments have arrived in India of which 9 came direct from England, the other 5 from South Africa, (3 in 1902); of 61 Infantry Corps only 11 came direct from England.

noted, further, that the Cavalry is usually located in comparatively small isolated bodies among larger aggregates of several units; the Cavalry strengths are comparatively small and a few cases yield high ratios when compared with those on a larger body of men. For it is a characterstic of the epidemiology that the disease does not, as a rule, appear in typical explosive epidemic form, but rather in capricious selective outbreaks, only a few cases appearing to own a simultaneous common origin, and these are linked on at intervals to similar restricted outbreaks or to single cases. A whole garrison is rarely, if ever, attacked equally and generally, but the majority escape, and this serves to lower the calculated rates in proportion to the size of the community exposed. The aggregation of a comparatively small number of men, with a very high proportion of susceptible individuals, tends to give to an outbreak a more epidemic *facies*; we see how in the case of small-pox the unvaccinated are not only exposed to the greatest risk themselves, but are a source of danger to the vaccinated, by multiplying the foci of infection and, possibly, by enhancing the virulence of the infection. And this is the case with the Cavalry and the other troops cantoned with them; there is, moreover, a marked tendency for the phenomena to be repeated in subsequent years and not to be confined to newly arrived regiments, a fact which would seem to point to the operation of the special local conditions to which the mounted arm is subject,—the maintenance of local foci of infection in the lines. Then also a far larger proportion of the mounted arm is constantly employed in the annual exercises and manœuvres in camp than is the case with the Infantry.

Lastly, in connexion with the foregoing considerations, it is not surprising to find that when the incidence on the Cavalry is compared with that on all other Arms located in the same stations, the former exhibits clearly the special liability of the Cavalry to suffer under what may be deemed, *prima facie*, fairly equal local conditions. In the period 1895-99, the rate of attack on the Cavalry was equal to 41·4 *per mille*, while that on the other Arms with nearly three times the strength, in the same stations in the same years, was 30·2; but, as we have seen, neither the local conditions nor the *personnel* exposed can, in fact, be considered equal in the two contrasted bodies.

This brings us, finally, to the position of the mounted Artillery in the list, intermediate between that of the Infantry and the Cavalry, but much closer to the former, and it is only necessary to remark that this position is evidently the resultant of mixed and opposing factors. While in many respects the conditions under which the mounted Gunners serve in India approximate closely to those of the Cavalry, and so the incidence of Enteric Fever is correspondingly raised, yet, in other respects, there are obviously other factors which tend to modify the full operation of those conditions. For example, the age-constitution of the Artillery is definitely higher, and this Arm is not located exclusively in the endemic area, so that as regards both of the predominant factors—the susceptible host and the infected place—it is at a decided advantage.

We have now to touch very briefly on some of the characteristic features of the disease as it occurs in separate corps units. It has been noted that, apart from local (endemic) infection and from importation, the probability of the presence of one or more infected individuals in a body of men of the age-constitution and numerical strength of a regiment, must not be overlooked, if only on the basis of the prevalence of the disease in the civil community in its natural environment ; and that the influences of aggregation in barracks with resort in common, on the one hand to latrines and on the other hand to refectories, together with a complete change of environment, must favour the spread of infection when present. Evidence has been adduced to show the persistent adhesion of infection to corps, despite changes of location ("infected regiments", Chapter V.) ; the infection may be, often is, left behind in camps or cantonments to affect other corps subsequently occupying them, but it is also transported in the bodies of sick, convalescents and apparently healthy individuals.

We have to observe next that only a small minority of all corps units escape the obvious signs of infection within the first year of their Indian service ; the evidence as to this is consistent throughout the history of the disease in this country. Of 73 regiments and batteries which arrived in India in the period 1871-77 only 9 remained free from a record of Enteric Fever during the first twelve months after landing (12 *per cent*). In the four years 1895-98, when the disease was at its highest point of prevalence, the aggregate number of corps units exposed in India was 641, only 86 of these were reported free from attack (13 *per cent*) and only 12 of the 86 had less than one year's experience of the country ; but of these 12 units only two had had as much as 3 months' service in India. If we look to the returns for 1903, which are the latest available at the time of writing, we find that during the 15 months from October 1902 to the end of the following year, 38 units arrived in this country, *viz.*, of Cavalry 4, of Infantry 18 battalions, of Artillery, 16 batteries. Of these only one battery and one Infantry regiment were reported free from Enteric Fever in 1903; the former (a very small unit) was exposed for the whole period of 15 months, the latter for only $2\frac{1}{2}$ months.

It would be as wearisome as it is unnecessary to discuss *seriatim* the various factors already detailed, in their operation on separate corps units; we shall merely present a *précis* of the salient facts in the history of newly-arrived regiments during the first few years of their experience; these corps are not selected arbitrarily, but every one that disembarked in India at any time in 1895 is taken and the facts are given as to its previous location, the stations occupied, the numbers of drafts received and the Enteric Fever rates recorded from year to year.

TABLE XLII.

To show the experiences of newly-arrived Regiments during the first five years of Indian Service.

Name of Corps.	Years.	Whence arrived.	Where stationed in different years in India.	Number of Drafts each year.	Ratio per 1,000 of strength — Enteric Fever. Admissions.	Deaths.
4th Dragoon Guards...	1895	England ...	Rawalpindi ...	45	40·8	14·68
	1896		Do. Dett. at Topa ...	64	33·1	9·92
	1897		Do. and Peshawar ...	151	78·7	26·22
	1898		Peshawar ...	100	58·1	10·56
	1899		Do. ...	53	60·1	15·90
20th Hussars ..	1895	England ...	Mhow ...	...	...	...
	1896		Do. ...	27	51·8	6·69
	1897		Do. ...	150	71·9	22·81
	1898		Do. ...	84	87·0	16·30
	1899		Do. ...	97	51·4	12·41
1st E. Yorkshire ...	1895	Egypt ...	Belgaum ...	...	...	...
	1896		Do. ...	151	5·0	1·01
	1897		Do. ...	120	12·2	5·07
	1898		Do. ...	80	3·0	1·00
	1899		Do. ...	242	7·2	3·10

TABLE XLII.—*contd.*

Name of Corps.	Years.	Whence arrived.	Where stationed in different years in India.	Number of Drafts each year.	Ratio per 1,000 of strength. Enteric Fever. Admissions.	Deaths.
2nd S. Staffordshire ...	1895	Egypt ...	Wellington ...	...	...	...
	1896		Do. ...	201	34·4	15·18
	1897		Do. and Thayetmyo...	199	18·6	5·87
	1898		Thayetmyo ..	61	...	...
	1899		Do. and Umballa ...	161	7·5	2·81
1st Wiltshire ..	1895	Aldershot ...	Kurrachee ...	...	...	...
	1896		Do. Dett. at Hyderabad.	165	12·0	4·00
	1897		Do.	...	8·9	4·92
	1898		Do. and Quetta ...	200	148·2	54·28
	1899		Quetta ...	287	10·0	2·00
2nd Rl. Irish Rifles ...	1895	Malta ...	Bombay ...	45	18·8	5·54
	1896		Do. ...	241	10·4	5·19
	1897		Poona ...	...	12·2	2·21
	1898		Do. ..	117	2·3	...
	1899		Do. $\frac{2}{3}$ mo. ...	Left for	England.	
No. 12 Co., Eastern Dn., R. A.	1895	England ..	Campbellpore ...	...	11·2	...
	1896		Do. ...	...	23·3	11·63
	1897		Do. ...	12	44·4	11·11
	1898		Mooltan ..	24	54·9	10·99
	1899		Mooltan $9\frac{2}{3}$ mo. and left for England.	8	40·5	13·51
No. 24 Co., Eastern Dn., R. A.	1895	Gibraltar ...	Colaba ..	...	15·1	7·52
	1896		Do. ...	...	...	...
	1897		Do. ...	. .	16·0	...
	1898		Do. and Delhi ...	26	...	..
	1899		Delhi and Fort Chingrikhal.	25	7·9	7·94
1st Royal West Surrey	1895	Malta ...	Umballa ...	..	64·3	14·29
	1896		Do. and Dagshai ...	255	45·5	12·42
	1897		Do. ...	120	105·1	11·36
	1898		Rawalpindi, Jumrood	195	33·3	5·33
	1899		Do. and Camp Gharial.	119	15·9	2·12
1st Scottish Rifles ...	1895	England ...	Shahjahanpur, Chaubattia and Bareilly.	...	34·4	8·60
	1896		Do. ...	240	3·0	·99
	1897		Do. ...	140	9·6	4·25
	1898		Bareilly and Lucknow	101	41·2	11·76
	1899		Lucknow and Ranikhet.	142	26·4	6·01
2nd South Lancashire ..	1895	Egyp ...	Kamptee ...	...	17·1	4·88
	1896		Do. ...	50	15·2	6·51
	1897		Do. ...	262	14·4	5·56
	1898		Do. ...	100	49·3	14·24
	1899		Jubbulpore and Saugor	161	26·2	6·28
1st Shropshire L. I. ...	1895	Hong-Kong	Calcutta ...	...	11·8	6·42
	1896		Do. ...	168	11·8	5·36
	1897		Benares ...	233	62·3	16·15
	1898		Sitapur ...	211	10·3	4·59
	1899		Poona and Colaba ...	92	5·1	3·06

It would be impossible to analyse all the factors which have operated to produce these results which, at a first glance, may seem to follow no definite laws; but while trying to avoid the reproach of vain repetition, we may note the probable influences of *personnel* (the human host factor) and of place in their varying degrees, and while sometimes these factors co-operate, at others, they are opposed. And more than this; a factor that for convenience is apt to be regarded as operating in one direction may, assuredly, tend on the one hand to decrease the amount of susceptible *personnel* at risk, and on the other hand to increase the amount of infective material and its chances of importation; take, *e.g.*, the different effects of the previous experience of the disease to which the corps have been subjected. Regiments that have been located in Mediterranean, Egpytian or South African stations before arrival in India, must have had an uncertain number of their most susceptible subjects eliminated from further risk of attack, but infection being present, there is the greater risk of its importation. If the synopsis is studied in the light of these considerations, much of the apparent caprice and many of the obscurities will disappear. We have, then, to distinguish, or combine, as the case may be, the influences :—

I. Of Locality ; (*a*) as regards previous experience of the disease ; some corps arrive direct from the United Kingdom, others from a tropical or subtropical environment where Enteric Fever is endemic, where the influence has the two-fold aspect noted: (*b*) as regards location in India, whether within or without the endemic area ; and with this must be considered the influences of aggregation (number of units and total strength in the station), of movements, dispersion in detachments which maintain connexion with the main body, of campaigns, etc.

II. Of *Personnel*, chiefly as regards the age-constitution and Indian service of the corps units ; numbers and frequency of the drafts received ; previous experience of the disease and probabilities of importation of the infection.

Further light may be thrown on some of these points by an analysis of a larger body of evidence derived from the records of the last three years for which data are available. We may compare the incidence of Enteric Fever on the corps which came to India from South Africa with that on the troops who arrived direct from the United Kingdom, confining our attention in both categories to men having less than two years' service in India. In 1902, the average strength of the corps which had come from South Africa during the whole of that and the previous year was 5,787, while that of the men having less than two years' service who arrived direct from the United Kingdom was 5,906; the admission and death-rates from Enteric Fever during the year in the former body were 24·4 and 5·88 *per mille;* in that of the latter 59·4 and 15·41 *per mille,* respectively. Taking the same data for 1903, the corps from South Africa, average strength 16,568 (with less than two years' service in India), yielded rates of 26·1 and 4·77 *per mille* of average strength, while the men who arrived direct from the United Kingdom, average strength 7,582 (with less than two years' service), suffered at the rate of 50·1 and 12·0 *per mille,* respectively. Again, during the year 1903, twelve Infantry regiments arrived in India,—nine from South Africa, one each from Egypt, Ceylon and Hong-Kong—the average annual strength being 9,325; the mortality rate from Enteric Fever among these troops was 4·18 *per mille,* that for the rest of the forces in India, of all ages and periods of service in the country, being identical, 4·18. There were no regiments direct from the United Kingdom in the same year to afford a comparison, but previous records leave no doubt as to their much greater liability to suffer on first arrival, and nothing further need be urged on this point. It is obvious that the factor of age enters into the above comparisons, and should properly be excluded for a just estimate, but inasmuch as it has been shown conclusively that the predominant predisposing factor is the first exposure to the Indian environment, we may surely trace the indubitable effects of previous experience of the disease in these results. When we find an exception to the general rule and the greater incidence of the disease on a corps is deferred to its second or third year of residence, it may often be traced to association in time and place with an unusual prevalence of the infection among other corps, and this generally among recent arrivals. The causes which conduce to an outbreak among the new arrivals have occasionally a similar effect on older residents in close association with them.

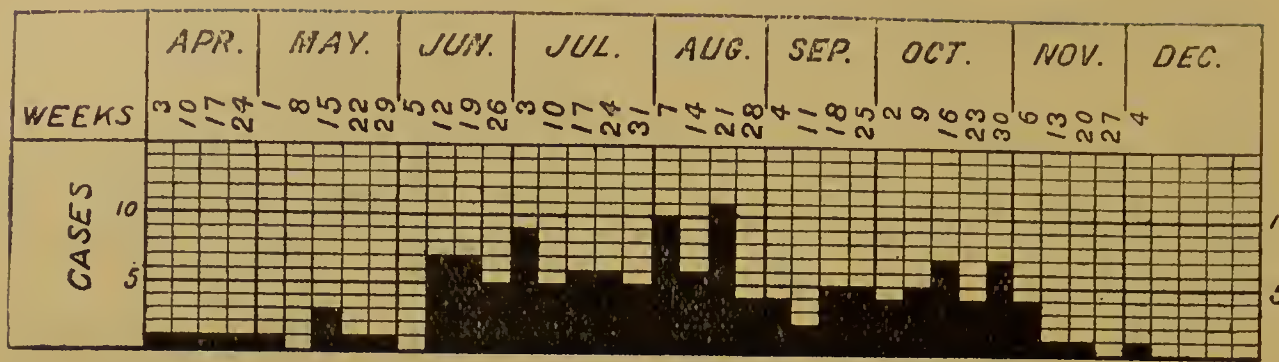
But these effects do not extend beyond a relative degree of immunity; previous experience in other tropical or sub-tropical stations places corps at an advantage in comparison with regiments which are transported direct from the Home country, but this of course is paid for elsewhere; the age-factor also comes into play, and when this is taken into account, there still appears to be a special risk incurred by the former when exposed to the conditions in India, and we may look for the explanation of this to the importation of the infection and to the greater strain imposed by the environment. The facts regarding the incidence of the disease on corps arriving from foreign stations furnish an additional explanation of the decline in the rates which has marked the period of the Boer war and subsequent years, for although the drafts direct from England were greatly diminished in numbers, and there was consequently a far smaller actual amount of susceptible *personnel* at risk, yet these suffered in proportion to their strength in practically the same ratio as during the period of greatest prevalence. One practical indication, which can only be alluded to in passing, is the necessity of well-directed efforts towards the prevention of the importation of infection; no corps coming from a foreign station with a history of the disease should be allowed to proceed to an Indian cantonment, or to mingle with other troops, until all possibly infected men and *matériel* have been isolated and disinfected.

As regards the other points bearing on the influence of locality and *personnel* little remains to be said which is not indicated in the synopsis given. A list of the corps units which have suffered most severely almost invariably shows their association with a few stations in the endemic area which constantly recur in the list of localities with the highest incidence; the effect of the numbers of men received as drafts from the United Kingdom is equally obvious, though there is not invariably a direct and immediate relation to be observed between the Enteric rates and the supply of drafts. The exceptions to the rule merely emphasize the necessity of avoiding a partial and exclusive view of the etiology, and, further, make it difficult to subscribe to the theoretic assumption of the omnipresence of the infection in the environment.

Taking a narrower field of observation, we have now to offer a few remarks on the subject of Company and Barrack infection. The difficulties presented by an enquiry into this aspect of the epidemiology are specially baffling under the conditions prevailing in Indian cantonments. The extended site over which the majority are spread, the number and nature of the water-supplies available, the numerous local foci of infection provided by the latrines and the faulty methods of conservancy, the dispersion of corps units into detachments with the constant intercommunication of these with the main body—all these factors operate to obscure and complicate the chain of evidence. Further, we must take account of the non-recognition of light cases which either never come under observation or are regarded as one or other of the anomalous forms of "fever"; of the disinclination of the men to report sick when attacked until a late stage of the infection; of the station-hospital system which involves the admission of men of all the different corps units into one institution; and, finally, of the restricted conception of the nature, the sources and the viability of the infective agent which has dominated medical opinion in the past and has not yet been altogether and everywhere revised. Consequently, we meet constantly with the remark in the official Reports that no special implication of any one Company or Barrack community was observed in an outbreak, that the disease claimed its isolated victims with indiscriminate caprice from all or nearly all sub-sections of a corps. The almost universal note struck is to preclude the idea of any common, simultaneous agency which gives to outbreaks due to the specific pollution of a modern water-supply system its explosive character. The larger outbreaks appear as an extension of the smaller series of linked infections, owing to the multiplication and extension of the foci of infection, and in these there is often undoubted evidence of simultaneous infection extending to two or three or even more cases, to be followed by a longer or shorter interval of abeyance. We get nothing like the familiar sudden steep leap of the curve of incidence to the maximum, with the characteristic abrupt but more gradual decline, which marks an outbreak due to specific pollution of one common source, water-supply or other; the curve is either maintained at a comparatively low and consistent level with slight fluctuations, or it is broken up into a series of a few cases at longer or shorter intervals. And this phenomenon cannot be attributed solely to the nature of the community exposed, as characteristic explosive "water infection" curves have been frequently observed in outbreaks in regiments on the Continent (Europe), and indeed, from the large proportion of individuals at the most susceptible ages present in a regiment, we should expect the explosive epidemic *facies* to be exceptionally well developed if the infection were due to an agency operating suddenly from one common source. It will make the position clearer if we take an example typical of the severer outbreaks in an Indian station and exhibit the number of cases admitted weekly, in the form of a chart (No. XVIII, next page), which shows the course of the disease at Quetta in 1896 (April to December), the total number of cases recorded being 141 (see A.M.D. Report, 1897).

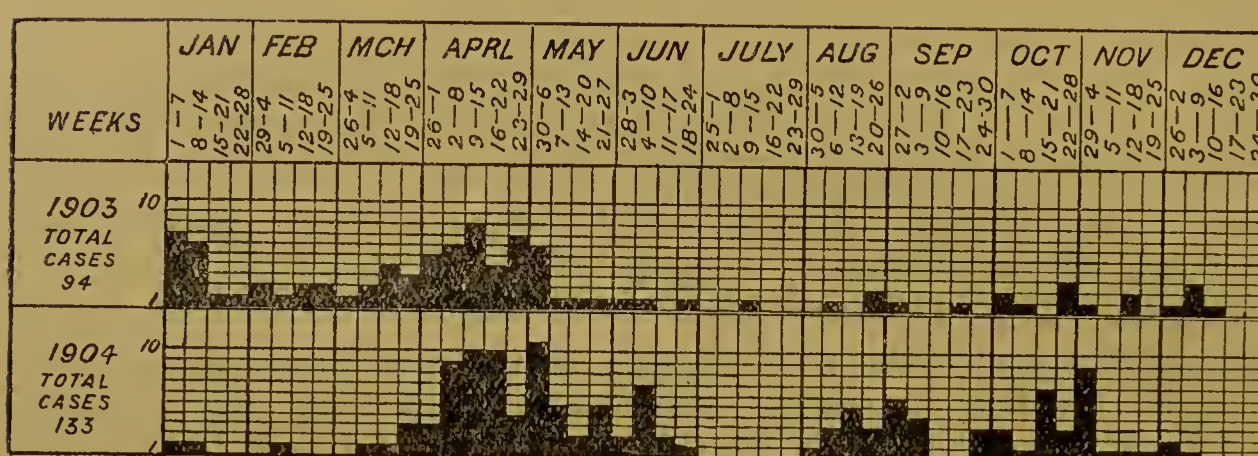
It is by no means suggested that water-borne infection is to be excluded on the evidence afforded by this graphic record ; there was, indeed, in this case much reason for attributing a considerable proportion of the attacks to this agency. "The year 1896 was an exceptionally hard one for the rank and file" (of which the strength was 2,300). "Field days were much more numerous than is usual in the hot weather. On many occasions the men did not return to barracks until past 10 A.M. having been out for some four hours marching and manœuvring all the time. They fell out of the ranks in numbers, and drank any water they could get—principally from irrigation channels" (page 490). It is to be observed, however, that these influences could only have been in active operation during the early stage of the outbreak and do not account for the maximum incidence in August and September, which, as has been seen, is the season of election for the prevalence of the disease in this place (Chapter IV.). We have always and everywhere to distinguish between the first sources of infection which may be present either within or without a community, and its subsequent propagation. It is impossible to say from the evidence whether the irrigation channels were first infected by the troops themselves, as is not improbable under the predisposing conditions present, but once the infection was introduced, it is scarcely open to question that the spread of the disease was due to the multiple foci established later within the cantonment. In so far as the water-supply can be implicated in such outbreaks, it is rather as the agent of the introduction of the infection, and then, further, as the readiest fortuitous vehicle by which widespread infection gains access to the body, but which otherwise would take a more indirect course. And thus infected water must be deemed to play a more secondary rôle than is usually ascribed to it on current theories of the epidemiology based on European experience. It cannot fail to take its place among the means of infection, but in the conditions prevailing

CHART No. XVIII.



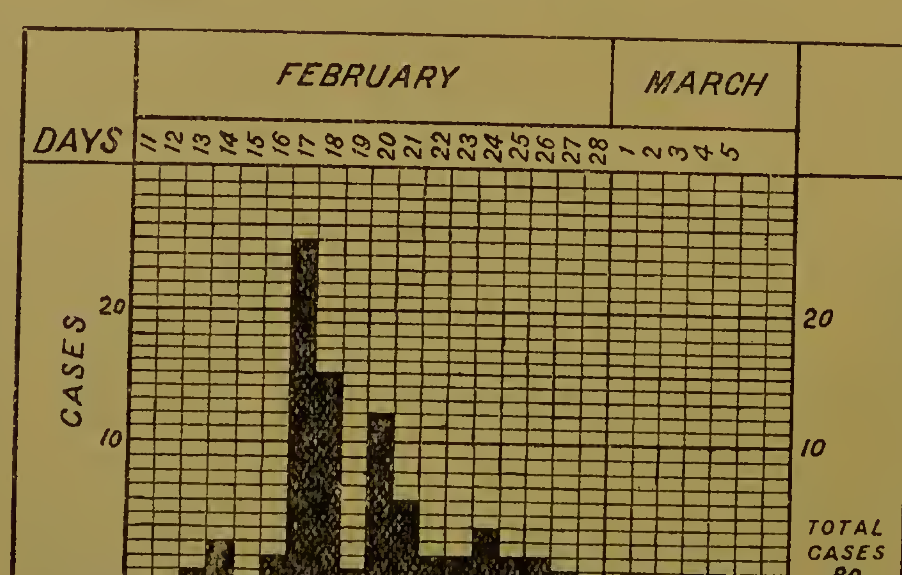
Enteric Fever at Quetta, 1896. To show number of admissions in each WEEK.

CHART No. XIX.



Enteric Fever at Lucknow, 1903 and 1904. To show number of admissions in each WEEK.

CHART No. XX.



Outbreaks in a German Regiment; water infection. To show number of admissions DAILY. Compare with Indian Epidemiology as shown above. (See Chapter VII.)

"*Zeitschr. f. Hygiene*," *Vol. XLVI.*, *p.* 23, 1094.

in an Indian cantonment, it is only one of several means which derive their opportunities and effectiveness from the multiple foci established and constantly replenished under the system of conservancy in vogue. If the distinction here drawn be regarded as only relative and one of degree, it is still one of the utmost practical importance as regards the main point of attack on the problem of prevention.

The characteristic incidence of the disease as exhibited by the course and connexion of the infections in time, touches the root of the etiological problem and deserves more space for its discussion than can be afforded here, but one more illustration may be given from the records of one of the chief stations in the endemic area: the chart No. XIX, p. 288, shows the number of fresh cases admitted week by week during the last two years (1903, 1904) in Lucknow, the lower curve being read as the direct continuation of the upper one. (See Chap. VII.)

It is necessary to add that these examples (from Quetta and Lucknow) are selected as representative of the severer outbreaks in the largest garrisons, where the conditions are favourable to a sudden epidemic outburst, and, consequently, the characteristic incidence is an exaggeration of the course of events in the majority of stations; but even so, it lacks the typical *facies* of a general infection from one common source to which a community is simultaneously exposed. Beyond the characteristic features already noted, we see from this how the sources of infection may persist in a large cantonment throughout the year under all the varying climatic conditions, and we are again forced to the conclusion that, whatever be the truth as to the exact extent of the risks of infection outside the site occupied, the specific virus may undoubtedly be constantly and abundantly present within cantonment limits, *i.e.*, in the infected men and in their immediate environment. To look beyond these for the sources of infection is only justifiable in so far as it extends and supplements the view of all the possibilities, one of which too frequently overlooked, is that of the dissemination of the virus by the men themselves in outside haunts to which they are accustomed to resort, bazaars, brothels, etc. Nothing is more certain than the fact of such dissemination, having regard to the prevalence of the disease among the men and to the extent and nature of their intercourse with the native community; and nothing is more probable than the risk of infection to which the previously uninfected individuals among them are exposed in the same haunts. We cannot therefore exclude outside *foci* of infection from a comprehensive view, but their significance is derived in the main from their association with the intra-cantonment *foci* of which they are an extension, the connecting link being the infected host. We cannot deny to a bazaar eating-house or brothel the very evident potentiality for evil which we are led to ascribe to the common refectories and latrines within the lines; all are the common resort of numbers of infected and susceptible men, and the circumstances which attend resort to the former are certainly at least as favourable to the dissemination of the infection. At the same time, there is the less need to postulate extraneous sources of infection altogether independent of the men themselves; the easy *prima facie* view based on the evidence of "bazaar infection" may well (and frequently does) involve a false assumption and an inversion of the true sequence of events.

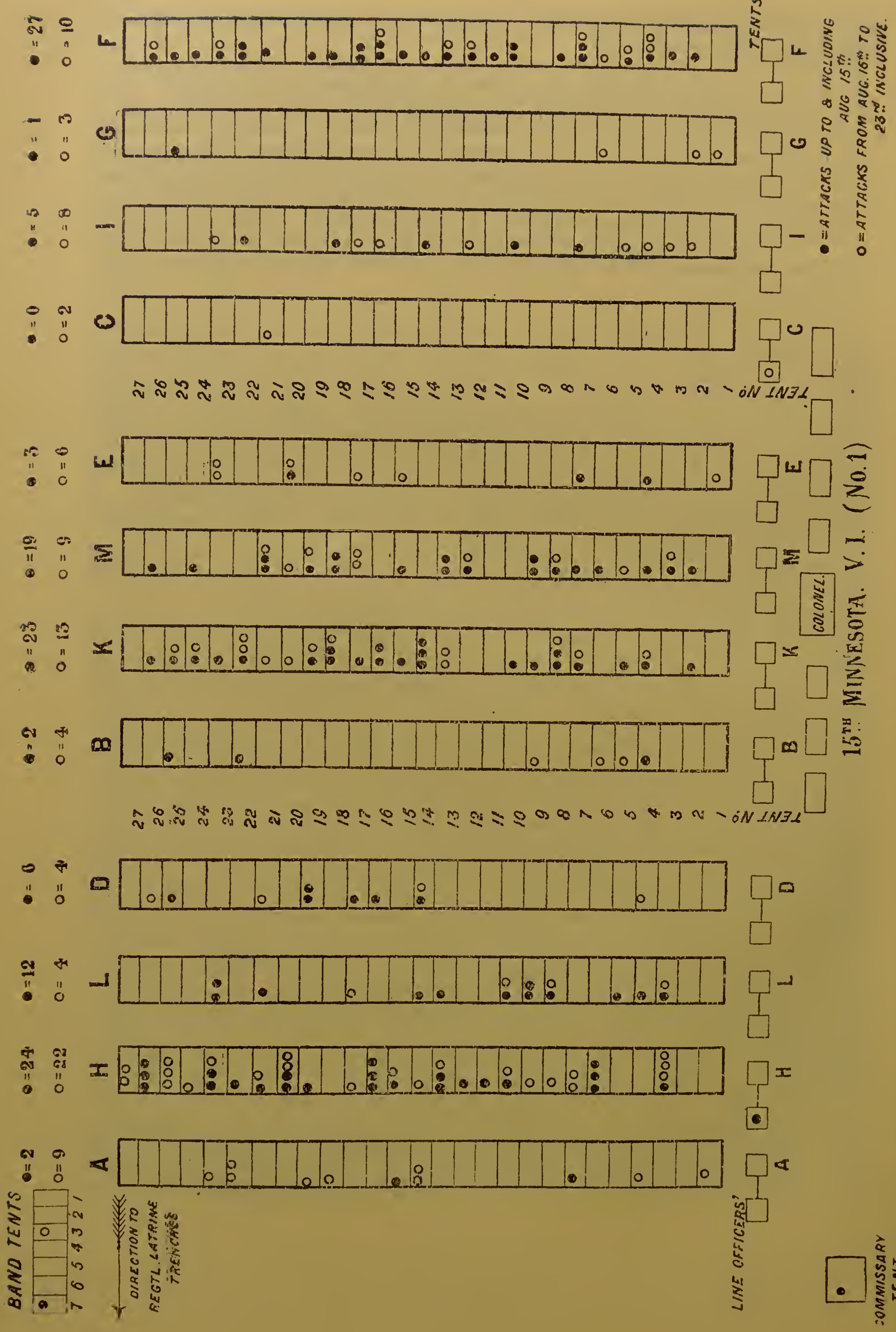
We may now turn to a closer examination of the facts bearing on the incidence of the disease on the smaller component elements of a corps unit, *i.e.*, on companies in isolated barracks, and the smaller aggregates occupying the same tent. In brief, we have to examine and appraise the influence of association, with all it connotes in regard to personal contact, direct and indirect, under the circumstances of a common "domestic economy". We should expect to obtain the most definite demonstration of this influence where the conditions as to aggregation are most marked and where other circumstances which ordinarily operate to minimise contact, direct and indirect, are, more or less, in abeyance. It will be obvious that such conditions are precisely those which characterize the aggregation of troops in camp, and when a larger number of different corps units from different localities are thus assembled, there ensues not only a marked enhancement of all the special disabilities of barrack life but there is the additional danger of importation of the infection. The salient fact that troops in camp are specially liable to outbreaks of Enteric Fever has long been established, but little attention had been paid to the means of infection, beyond vague assumptions in which pollution of the water-supply was generally invoked, until the assembly of the United States Army in the national camps in 1898 afforded an opportunity for the study of the question, which was used to the best advantage. A remarkable feature of the Report, to which allusion has frequently been made, is the discussion it presents of "company epidemics"; the Commissioners say:

> "it is only when we study the course of the sickness in the regiments from the standpoint of individual companies that we can adequately appreciate the fact that it is characterized by a series of company epidemics, each one having, more or less perfectly, its own individual characteristics. It is especially true when we regard the commencement, the exacerbations during the course, and the time of termination of these company epidemics, that they are rarely seen to be synchronous. With variations in the separate company epidemics, there is, as a rule, no striking similarity in the course of the outbreaks in the companies grouped together as regimental units."

In the next place, the evidence appears to demonstrate that, as regards the exacerbations which were noted in the course of these company epidemics, the intervals between them were "as a rule closely coincident with the average period of incubation of the disease". A still closer analysis of the data, with the aid of nominal rolls of the men occupying the same tents and of spot maps of the camps marked at different stages of the outbreaks, leads to the same conclusion as regards individual attacks; that is to say, that cases were found to occur in the separate tents at intervals closely approximating to the ordinary incubation period.

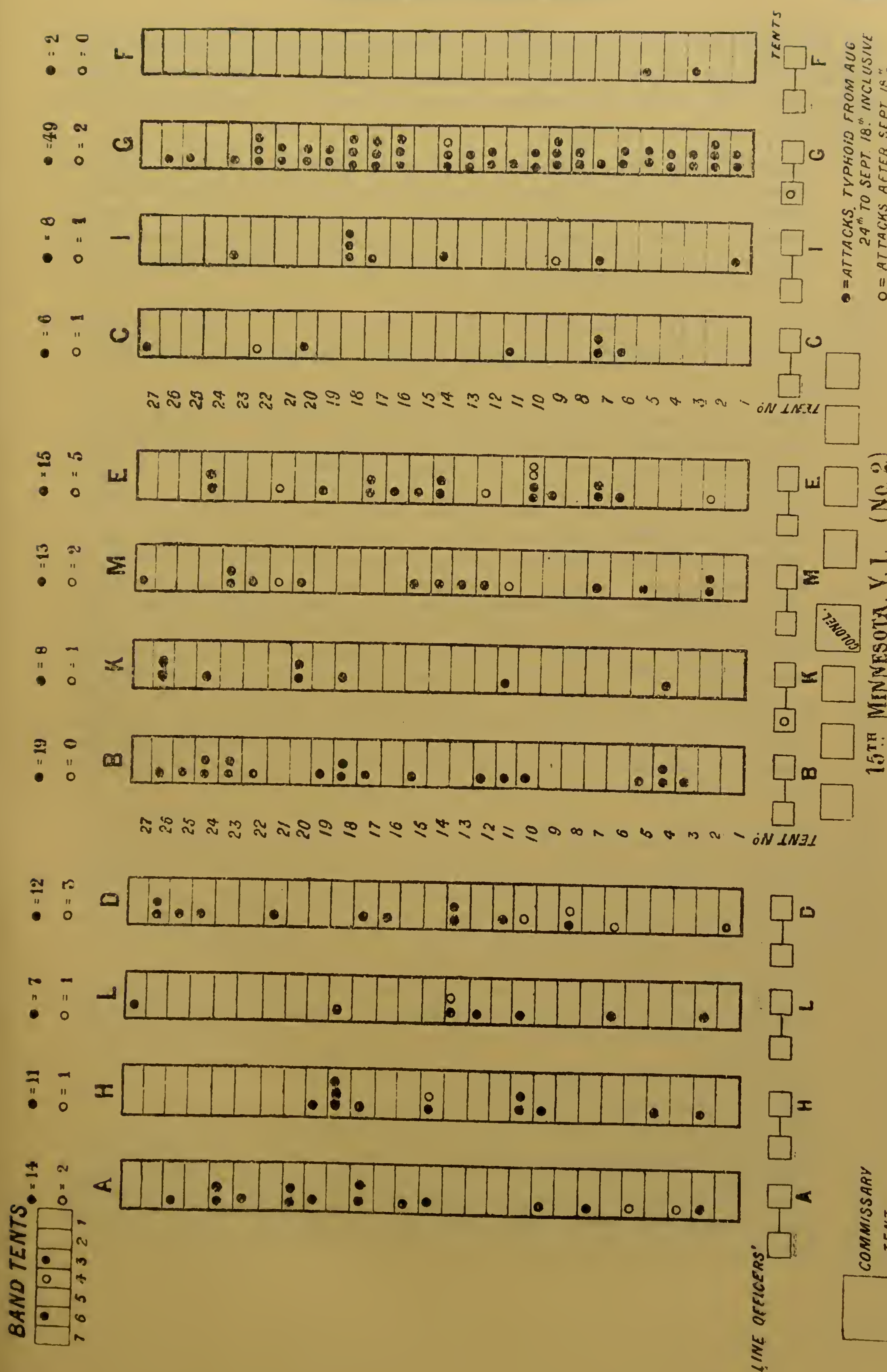
Two diagrams, copied from the American Commissioners' Report, are appended, which display the method employed in tracing "tent, squad and company infection". The regiment implicated is the 15th Minnesota V.I., of the experiences of which brief details were given in the preceding chapter. In the first diagram the attacks of Enteric Fever up to August 15th, when the corps first changed its camp, are indicated by one sign (black spot); those occurring from August 16th to 23rd, on which latter date the regiment moved to the State grounds, Fort Snelling, by another sign (small ring). In the second diagram, the attacks are again represented in two periods, the black spots denoting the cases occurring in camp at Fort Snelling, and the rings showing those which were admitted in the final period (from September 18th), after the men reached the National Camp at Meade. A study of the signs will show the manner in which the attacks were grouped in regard to certain companies and tents—

> "The groups of the sick as plotted in their tents would seem to be incompatible with the assumption that the chief factor in the propagation of the disease throughout the companies was some agency whose influence was common to, and constantly acting upon, the whole command".



15TH MINNESOTA. V. I. (No. 1)

(From Report on the origin and spread of Typhoid Fever in U. S. Military Camps during the Spanish war of 1898.)



(From the Report on the origin and spread of Typhoid Fever in U. S. Military Camps during the Spanish war of 1898.)

for the incidence was capricious; neighbouring and intervening companies (as located in the regular rows of tents) were found to escape the common experience to a greater or less degree. The data, on the contrary,

> "suggest a mode of dissemination which more effectively reached and acted upon certain limited groups of men, while it passed by others, which is entirely compatible with the assumption of a dominating tent or comrade infection; this was certainly the indication as regards the course of the disease during the period of the occupation of the camps, whatever the original source of the infection".

Moreover specific pollution of the common water-supply could almost as certainly be excluded from consideration. For example:—

> "Prior to the arrival of the troops, several deep wells had been bored, from which an abundance of good water was obtained; this was pumped into tanks of sufficient capacity and thence distributed through iron pipes under constant pressure to the several regimental camps. * * These deep wells were so situated as regards the camps as to be free from any danger of contamination from surface drainage. And again, since there was only one large regimental latrine for the use of all the companies in this camp, a mere reference to the relative location of the companies and that of the latrine at some distance from the extreme western flank of the camp, would appear to be sufficient to cast doubt on any common agency of wind or flies as playing a chief rôle in the dissemination of the infection, since neighbouring or intervening companies did not share the common experience. The evidence of the influence of personal contact—tent or comrade infection—derives its chief support, however, from an analysis of the records in connexion with the grouping of infected men in their tents and with the average time elapsing between successive or 'connectable' attacks in the same tent and in adjoining tents".

As deduced from these data, the Commission found that of 436 cases of Enteric Fever, occurring in the camp in question, no less than 317 (72·7 per cent) were separated or "connectable" by the average period of incubation. In a final summary of the results obtained on this point it is stated that—

> "Of 1,608 cases of Typhoid Fever, which we have been able to locate accurately in the particular tents in which they occurred, together with the dates of commencement of the attacks, the facts may be summarized as follows:—
>
> Directly connectable attacks, 563, or 35·01 per cent.
>
> Indirectly connectable, 447, or 27·79 per cent.
>
> Total connectable attacks, 1,010, or 62·8 per cent.
>
> Certain tents were badly infected and the majority of their inmates developed the disease, while other tents wholly escaped. Blankets and tents become soiled with typhoid discharges, and in this way the disease was propagated and carried wherever the company went. Personal contact was a very important factor in the spread of the disease".

It is impossible to read the foregoing description of the salient features of the incidence without being struck by the likeness it presents to the epidemiological *facies* of our Indian outbreaks. The circumstances prevailing in the American camps were peculiarly favourable to the elicitation of the epidemiological type, but these circumstances were, in all the main essentials, precisely those met with in Indian cantonments, in an exaggerated degree ; the demonstration of the results is consequently only clearer and more forcible, while the indications are identical. Unfortunately, the official records in this country do not often afford the necessary data for pressing home the parallel. A small minority only of the monthly Returns from Station Hospitals have hitherto given particulars of the names of Enteric patients and of the barracks occupied by them prior to the dates of admission, but these dates are wanting, and with them the chief clue to a possible connexion between the attacks; a simple outline plan of the cantonment, marking the barracks, latrines and sources of water-supply, and on which the location of all cases of Enteric, and of the so-called Simple Continued and Remittent Fevers, could be "spotted" with the dates of their occurrence, would afford evidence on this and other obscure points, the value of which would be great and out of all proportion to the time and labour involved. So far it has, as a rule, merely been noted in a general way that in the severer outbreaks, most of the barracks were more or less indiscriminately affected, as appears to be demonstrated by the capricious sequence of the serial numbers of the barracks from which cases are reported. Nothing could well appear more baffling to the *prima facie* view than the destroying-angel character of an outbreak in which the individual victims are struck down at various disconnected points of the occupied site, but little attempt has hitherto been made to trace the course of the disease within the smaller integral components of a corps, each with its more or less self-contained domestic economy, of common barrack, food and water-supply and conservancy arrangements. In so far, however, as these are shared in common to a greater or less extent, by more than one barrack or other unit, we should expect the operation of common *foci* of infection to obscure the issues and this in direct proportion to the multiplicity of the possible *foci*, latrines, wells, etc.; and thus the indirect means of the propagation of infection will assume a more important rôle. In the light of these considerations we may review the scanty evidence, the negative aspect of which must be duly appraised ; as attention comes to be directed to this relation in the sequence of cases in company units, the clue to many an outbreak will doubtless be elucidated.

As it is, references constantly recur of which the following is a typical example (Report of Sanitary Commissioner, India, for 1900, page 13):—

> "In a few cases it is stated that particular barracks or corps were more affected than others, or that the disease was equally distributed among them..................At Agra, 10 out of 19 cases came from two barracks that showed want of cleanliness. No reason could be discovered at Nasirabad why, though cases came from every barrack, 18 cases were admitted from Nos. 12 and 18. Nowgong's cases were all in the North Staffordshire Regiment, and none occurred in the Battery, which had been longer in India, and had suffered in 1898. Enteric at Thobba was confined to the Bedfordshire Regiment which had halted for one day at the Mian Mir rest camp".

Two of the most clear and convincing instances on record are derived from epidemics at Cherat the main facts of which are stated by Major Aldridge, R.A.M.C., in a very instructive contribution to the *Journal of Hygiene* (page 363, Vol. II, 1902). He refers to the :—

> "marked tendency for the cases to occur in groups, with an interval closely corresponding to the incubation period of the disease, suggesting that each group was infected by the former. Thus one barrack furnished a first case on May 27th, the second case 14 days later, a third 15 days later, and, after another interval of 10 days, six cases between July 5th and 20th. Another barrack had its first case on June 19th, two cases following on 25th and 28th ; then after an interval of 16 days, five cases between July 14th and 23rd, and one more case after an interval of 11 days. A third barrack, commencing on July 7th, had five cases in five days, and two more cases later. Both epidemics attacked chiefly (one almost exclusively) the occupants of barracks at one end of the station, close to the incinerator, where fæcal matter was continually standing in heaps mixed with day refuse. * * The water was derived from protected springs, four miles distant from the station and well away from any apparent source of contamination ; the water was, however, stored in barracks, in loosely-covered vessels, and dust storms were of frequent occurrence".

Nothing could well be more cogent than this simple statement, and it cannot be doubted that it represents a far more common experience than the defective data enable us to establish, but the indications all tend to this conclusion though the evidence is generally obscured by the failure to grasp the clue and by the endeavour to enforce the prevailing and partial view of the etiology. Many examples could be drawn from the official Reports, which derive additional weight from the fact that they are presented to support a totally different theory of dissemination.

Lieutenant-Colonel Davies, R.A.M.C., has also recorded the above-mentioned instance (Cherat), and others within his own experience. Thus at Dagshai in 1897, there were 66 cases returned within the space of 3 months, and of these 25 occurred in two Companies, D and F, of the Queen's regiment; the dates were as follows :—

D Company.			F Company.		
March	...	24*	May	...	6*
,,	...	29	,,	...	10
April	...	4*	,,	...	18*
,,	...	10	,,	...	30*
,,	...	12 (2 cases)	June	...	24*
,,	...	13 *	* ,,	...	26
,,	...	15	,,	...	27
May	...	7*	,,	...	28 (2 cases)
,,	...	23*	,,	...	30 (2 cases)
June	...	14*	July	...	1
July	...	3*	,,	...	4 *
			,,	...	6

The intervals occurring between the dates marked by asterisks are suggestive. Again, in Quetta, in 1898, where there were 216 cases, it is noted that some bungalow barracks were severely affected, while others escaped entirely. From No. 9, accommodating 128 men, the cases were admitted on the following dates :—

July	6*	August		September	20*	October	11*
,,	17*	,,	6*	,,	24	,,	13
,,	26*	,,	25*			,,	20*
,,	29	,,	28			,,	26
,,	30					,,	30

and from No. 11, as follows :—

July	8*	August	1	September	5*	October	
,,	17*	,,	7*	,,	7	,,	4*
,,	29*	,,	23*	,,	17*	,,	11*
		,,	25	,,	27*	,,	12
				,,	29		

It will be observed that the general tendency is to very small group infections linked up by cases at intervals of one to two weeks, and this is very suggestive of direct contact on the one hand and to local ectanthropic *foci* on the other hand, the one supplementing the other. But both come within the terms of our definition of "contact infection," the one more immediate, the other mediate, or more or less indirect.

For an instance, at the opposite extreme of the historical record, at a time when it was generally held that Enteric Fever was not "contagious," and no suspicion of contact infection ever arose, a reference may be made to the A. M. D. Report for 1880, in which an excellent account is given of an outbreak in the West Riding Regiment at Lucknow. In all 16 cases were recognized, and 12 of these occurred in three companies (F, C, and D) the aggregate strength of which was 301 men, the latrine accommodation for whom was in common and limited to only 16 seats. The first cases were admitted from F company on March 19th and 22nd, followed at an interval of 28 days by a group of 5 cases (April 20th to 26th), three of which came from the same barrack and one each from C. and D. The next two cases were from barracks contiguous to C, and were recognized 14 and 20 days respectively after the date of C case. After a further interval of 23—25 days, two more cases appeared in F and one in C, followed after 8 days by one in D. So far the sequence of events is extremely suggestive ; the last 3 cases of the series were not, however, admitted till after a further interval of six weeks, one from D, one from E contiguous to F, and one from H, at a considerable distance from the previously infected barracks. The following statement will give a clearer synopsis of the course of events :—

Intervals.	Dates of admission.		Company affected.
	March	19	F.
	,,	22	F.
28 days.			
	April	20	F.
	,,	22	F.
	,,	22	D.
	,,	24	C.
	,,	26	F.
11 ,,			
	May	8	B.
	,,	14	G.
23 ,,			
	June	7	F.
	,,	8	F.
	,,	10	C.
8 ,,			
	,,	18	D.
42 ,,			
	July	31	E.
	August	2	D.
	,,	11	H.

NOTE.—Latrine accommodation common to Barracks F, C, and D.

It must be remembered that at that time (1880) and for many years later, only the most pronounced and typical clinical evidence was accepted as establishing the diagnosis, and that if we could fill up the series with the light and unrecognized cases, which doubtless occurred, the chain of connexion would be even more clearly demonstrated. The intervals between the recognized cases must also be read with a due appreciation of the considerable range of the incubation period, along with the fact that different individuals report illness at different stages of the infection.

Another instance may be given (from the Report of 1882) which suggests that an acquaintance with the facts in this respect would probably throw a very different light upon a typical outbreak which baffled the detective faculties of the local observers :—

'The distinctive feature of the outbreak at Cawnpore was its restriction to the men of the Scottish Rifles, the officers, women and children of the regiment escaping, and also the Royal Artillery. In the Battalion also the incidence was most unequal; the men were quartered by companies in separate barrack blocks arranged in an echelon line running from north-west to south-west, and, so far as can be ascertained, not a single other discriminating difference than this of lodging was to be found; the ages of the men of the several companies if not in a close average, were not strikingly dissimilar; if certain companies contained a large number of men who had suffered from Enteric Fever in their recent previous service in South Africa, and had thus exhausted their comparative susceptiblity to attack, the fact could not be brought out with such certainty as to justify the assumption that the difference in the rates of attack in the various companies was consequent on this circumstance. At the northernmost end of the line, No. 1 barrack block was unoccupied by the troops, the accommodation was not required, and its history in relation to cholera (it being often the first building in which the disease appeared in an epidemic) gave it a reputation for general unhealthiness, causing it to be left untenanted when possible. The 8 companies of the battalion (from A to H) were lodged in the remaining barrack blocks. "A" company was lodged in No. 2 block, the next to the presumably unwholesome one, the remaining companies being lodged in the other blocks in order. Ten out of 18 admissions during the outbreak were from "A" company (2 block), the remaining cases being scattered over the other blocks. The excessive unhealthiness of "A" company in No. 2 block is most apparent as judged by the evidence of cases of illness arising in it, whether called Remittent, Enteric or Simple Continued Fevers. In a special report received in connexion with the occurrence of this outbreak, its causation was traced to various agencies, some of these, such as a water-logged state of some neighbouring grounds, might be potent in the production of Paludal Fever; others, again, such as the bad ventilation of No. 2 block, and the proximity of an old cemetery might conceivably induce some form of Typhus Fever, but no cause capable of originating Enteric Fever in that block was suggested. It should be remarked that all the barrack blocks are two storied, and that in No. 2 block of 10 admissions, *nine were those of men lodged in the upper story*.

If we pass on to the most recent records, we find instances like the following, which, to say the least, are very suggestive.

At Rawal Pindi in 1903, there were 59 admissions from Enteric Fever which may be considered as occurring mainly in two separate outbreaks of connected cases. The first series comprising 24 attacks, occurred among the men of the 9th Lancers, the majority being admitted between the end of March and September. It is reported officially that a trooper belonging to "A" squadron, and who was one of a draft which had arrived in India less than four weeks previously, was recognized as suffering from the disease in the end of March; "27 days later another man from the same squadron was admitted, a third followed from the same squadron in 11 days, a fourth 25 days later. From this time the cases became more frequent and their distribution more general; 5 occurred in May, 6 in June," and so on, details not being given of the dates and barracks.

The next series of 17 cases occurred in the Wiltshire Regiment late in November. "Here again there was no doubt that the disease was introduced by a member of the last draft recently arrived in the station: he came to hospital on November 25th, and two more were admitted on 26th and 27th, both men of the same draft." These three men all arrived at Pindi on 17th, 8, 9 and 10 days, respectively, before admission to hospital, leaving little doubt of the fact of importation. Case No. 1 came from No. V Barrack, while cases 2 and 3 came from Barracks Nos. II and III, which had one latrine in common use and which were separated from Barrack No. V by cross roads and other buildings. There were evidently at least two distinct foci of infection at the commencement, *viz.*, in the latrine of Barrack No. V and in that common to Barracks Nos. II. and III.; the dates of the first and subsequent cases are given as follows:—

Barrack No. V.		Barracks Nos. II. & III.	
Case No.	Date.	Case No.	Date.
1	November 25th (imported)	2	November 26th (imported)
7	December 11th	3	,, 27th (imported)
10	,, 17th	4	December 5th
12	,, 19th	6	,, 9th
13	,, 24th	8	,, 12th
14	,, 29th	9	,, 13th
17	,, 30th	11	,, 18th
		15	,, 30th

We see that after importation, the first subsequent case, in each instance, was admitted after an interval which corresponds with the ordinary incubation period, 10–16 days; thereafter as regards Barrack No. V., there is a suggestive relation between the dates of cases No. 1 and Nos. 7 and 10, between Nos. 7 and 12 and 13, and between Nos. 10 and 12 (together) and Nos. 14 and 17 (together). In Barracks Nos. II and III, a similar connexion may have existed between case 3 and cases 6, 8 and 9, case 4 and case 11, and between the latter and case 15. Of course, it is impossible to connect these events with certainty on the data available; it is merely claimed that the relation is suggestive; other men of the draft which imported the disease were infected, and these may have provided links in the chain of connexion; we incur the risk of fallacy in endeavouring to fix arbitrarily the incubation period, which may vary in length from one to four weeks, especially when dates of admission to hospital are relied on and when patients are prone to neglect to "report sick" as long as possible.

Some examples may be given, in conclusion, from the returns of 1904, the facts being obtained by special enquiry. The following statement shows the dates of the admissions from most of the different Barrack blocks in Lucknow, a few being omitted where the cases were rare.

Dates of admissions from different Barracks in Lucknow—1904.

No. 1.	No. 2.	No. 3.	No. 4.*	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
...	...	...	5·2	...	...	...	...	...	...	...	..
...	...	...	22·3 }	16·3	...	...	...	...	...	22·3	...
31·3	..	...	22·3 }	29·3	...	...	...	...	...	...	...
12·4	15·4 }	10·4	3·4	10·4	...	1·4	4·4	...	3·4	6·4	3·4
15·4	15·4 }	15·4	8·4	...	...	...	11·4	...	8·4	...	5·4
16·4	19·4	19·4	19·4	...	...	...	...	...	19·4	...	11·4
20·4	23·4	21·4	27·4	...	...	20·4	...	23·4	...	...	20·4
...	27·4	...	...	...	...	...	...	...	...	...	...
...	30·4	...	...	...	...	...	...	...	...	...	...
1·5	4·5	...	3·5	...	...	6·5		11·5	13·5	11·5	...
4·5 }	5·5	...	9·5	...	...	...	..	..	...	...	...
4·5 }	7·5	...	...	...	...	...	...	...	...	...	...

* No. 4 was the Hospital Orderlies' Barrack.

NOTE.—The figures show the date and the month, thus:—31·3 = 31st March.

Dates of admissions from different Barracks in Lucknow—1904—(continued.)

No. 1.	No. 2.	No. 3.	No. 4.*	No. 5.	No. 6.	No. 7.	No. 8.	No. 9.	No. 10.	No. 11.	No. 12.
...	17·5	...	...	...	14·5	..	...	...	...	...	...
...	26·5	...	21·5	...	...	24·5	...	25·5	25·5	...	...
13·6	9·6	5·6	1·6	...	...	9·6	18·6	10·6	5·6	...	...
..	4·8	...	7·8	...	11·8	...	...	...	10·8	...	...
23 8	...	24·8	24·8	...	19·8	...	...	18·8	14·8	...	
30·8	27·8	...	...	...	29·8	...	...	...	28·8	...	
...	...	...	...	...	...	...	...	...	28·8	...	...
...	...	...	3·9	...	...	...	...	...	2·9	..	...
...	...	...	4·9 }	...	...	...	...	...	...	...	.
	...	...	4·9 }	...	...	...	...	...	...	...	...
...	.	...	9·9	...	...	...	...	...	...	...	...
...	...	...	29·9	...	...	...	...	...	29·9	...	...
...	8·10	3·10	...	...	17·10	...	...	1·10	6·10	17·10	
23·10	19·10	19·10	20·10	...	...	...	21·10	...	...	...	...
29·10	...	31·10	30·10	...	...	...	...	29·10	...	...	28 10
...	27·11	4·11	...	...	1·11	...	...	...	...	...	...
...	...	5·11	...	...	3·11	...	...	...	...	...	...
..	...	...	...	...	24·11	...	...	...	...	...	...

* No. 4 was the Hospital Orderlies' Barrack.
NOTE.—The figures show the date and the month, thus: 31 3=31st March.

As regards Umballa, 61 out of the 105 cases reported from that station occured in Camp and, doubtless, many of the cases noted in Barracks were due to infection acquired in, or brought from, the Camp. It should be said that these cases (Umballa) were all returned by two regiments located in standing camps in the cantonments ; that the epidemic in the early months of the year was a continuation of an outbreak in the previous autumn, and that both corps passed the summer in different Hill Stations returning to Camp (Umballa) on October 18th and 28th, respectively, the first cases being admitted on October 27th and November 9th in each regiment, respectively.

See next page.

The following statement gives the results in five other large stations which were furnished at the writer's request :—

Enteric Fever.—Dates of admissions of cases from different Barracks in some of the largest Cantonments, 1904.

UMBALLA.

Serial number of the case.	Date of admission into hospital.
From the Camp.	
2	2nd January.
3	3rd ,,
4	4th ,,
5	5th ,,
6	7th ,,
7	8th ,,
8	10th ,,
10	12th ,,
11-12	14th (2) ,,
13	15th ,,
15	19th ,,
16	20th ,,
18-19	22nd (2) ,,
20	1st February.
21	2nd ,,
22	11th ,,
24	13th ,,
25	14th ,,
27	16th ,,
28	18th ,,
29	23rd ,,
30	11th March.
31-32	13th (2) ,,
33	18th ,,
34	22nd ,,
66	27th October.
70	9th November.
71-73	16th (3) ,,
75	20th ,,
76	21st ,,
77	22nd ,,
78-80	23rd (3) ,,
81	24th ,,
82	25th ,,
83-85	27th (3) ,,
86-87	29th (2) ,,
88	30th ,,
90	3rd Dec.
92	4th ,,
94	5th ,,
95	7th ,,
96	10th ,,
97	13th ,,
98	14th ,,
99	15th ,,
100	17th ,,
101	20th ,,
102	20th ,,
103	21st ,,
104	28th ,,
105	30th ,,

QUETTA.

Serial number of the case.	Date of admission into hospital.
From Barrack No. 2.	
4	11th May.
5	11th ,,
6	20th ,,
8	25th ,,
30	1st August.
33	16th ,,
44	14th September.
46	18th ,,
47	19th ,,
48	26th ,,
From Barrack No. 5.	
2	6th May.
7	23rd ,,
9	30th ,,
14	4th June.
From Barrack No. 9.	
15	15th June.
20	30th ,,
24	5th July.
27	24th ,,
From Barrack No. 10.	
60	9th November.
62	15th ,,
67	27th ,,
68	29th ,,
From the Camp.	
21	2nd July.
23	5th ,,
35	29th August.
37	31st ,,
38	3rd September.
39	3rd ,,
40	7th ,,
41	9th ,,
44	14th ,,

POONA.

Serial number of the case.	Date of admission into hospital.
From Barrack No. 2.	
26	17th August.
45	28th ,,
56	4th September.
From Barrack No. 4.	
13	7th August.
15	9th ,,
34	21st ,,
52	31st ,,
From Barrack No. 5.	
28	17th August.
42	25th ,,
43	26th ,,
58	7th September.
63	14th ,,
From Barrack No. 12.	
51	31st August.
57	5th September.
62	14th ,,
From Barrack No. 14.	
19	12th August.
25	15th ,,
46	30th ,,
From Barrack No. 18.	
21	13th August.
30	19th ,,
39	24th ,,
44	26th ,,
From Barrack No. 19.	
16	10th August.
24	15th ,,
31	20th ,,
47	30th ,,

MEERUT.

Serial number of the case.	Date of admission into hospital.
From Barrack No. 1.	
4	7th January.
6	10th ,,
7	18th ,,
20	28th March.
24	10th April.
25	11th ,,
35	17th ,,
36	20th ,,
42	27th ,,
48	5th May.
From Barrack No. 9.	
16	14th March.
21	31st ,,
24	10th April.
44	20th ,,
46	29th ,,
From Barrack No. 37.	
31	14th April.
43	28th ,,

Enteric Fever—Dates of admissions of cases from different Barracks in some of the largest Cantonments, 1904.—(continued.)

RAWALPINDI.

Serial number of the case.	Date of admission into hospital.	Serial number of the case.	Date of admission into hospital.	Serial number of the case.	Date of admission into hospital.	Serial number of the case.	Date of admission into hospital.
From Barrack No. 3.		*From Barrack No. 4.*		*From Barrack No. 13.*		*From Barrack No. 15.*	
20	14th May.	70	3rd December.	71	3rd December.	64	29th November.
23	27th ,,	75	14th ,,	82	21st ,,	73	6th December.
27	4th June.	84	28th ,,	83	29th ,,	76	15th ,,
30	10th ,,					77	15th ,,
35	16th ,,					78	15th ,,
37	19th ,,						
52	11th October.						
54	25th ,,						

All this evidence must be studied in the light of the considerations which have been repeatedly advanced and also with due reference to our definition of "contact" infection, which includes the operation of mediate *foci*, and especially those set up in places where the infection is most likely to be deposited and to find the conditions favourable to its viability; such places being also the centres of common resort, and in this respect the latrines and barrack dormitories take the most important place. From the outset we have insisted on the dangers of the present latrine system, and in the evidence submitted on the epidemiological survey this central consideration must be borne in mind. And, indeed, the general tendency of the most recent opinion among medical officers has been to ascribe more and more influence to this mode of infection. Major Weir, R.A.M.C., the Sanitary Officer of the Northern Command, has been specially active in promoting this view, and the Reports of the last two or three years are replete with instances in support of it (see also Captain Burke and Lt.-Col. Davies, R.A.M.C., in the *Journal of the R.A.M.C.*, for January and May 1905, respectively). We need not dwell further on this aspect of the case in direct connexion with the evidence of contact infection and its characteristic epidemiology (see Chapter VII), but as regards the local infection of barracks one instance may be added to those previously given in discussing importation, *viz.*, the outbreaks following on the return of the troops from the Franco-German war and that of the Portland barracks. (Chapter V.) The Officer Commanding the Station Hospital, Ranikhet, in referring, in a note to the writer, to an outbreak there in 1904, after discussing the possibility of a water-borne infection, dismisses it in favour of the actual presence of the infection in the dust and dirt which had accumulated in the particular barrack-room occupied by the affected corps. Of 24 cases recorded in the station, 15 occurred in the 1st Royal Sussex Regiment, of which 3 cases were imported from the Plains. "The flooring of the barrack-room, occupied by the company chiefly affected, was in a very bad state, with many cracks and a lot of accumulated dust and dirt beneath it. The flooring was taken up and renewed, the men being removed to tents during the work, and no more cases occurred."

Before leaving this subject we would suggest the desirability of comparing the charts illustrating the seasonal incidence of admissions (Chapter IV.) with those just given to show the weekly incidence in Lucknow and Quetta (p. 288); the latter furnish a corrective to the impression derived from the former as regards the epidemiological *facies*; the rises in the curves to the maxima are now seen to be spread more equally over several weeks of greatest prevalence and not to assume the typical characters of sudden and widespread outbursts as from one common source of infection operating generally on the whole community exposed.

Lastly, it is not easy to appraise the influence of contact infection in moulding the characteristic seasonal incidence; we must certainly expect it to operate to some extent if it be as important a means of propagation as the evidence appears to show. A large proportion of the younger and more susceptible subjects leave the Plains for the Hills by an early date in April after infection is well established, and there is little difficulty in accounting for the later April and May infections, which would certainly be more numerous in the Plains if there was no exodus to the Hills. There are evidently powerful influences at work to effect the marked decline in the infections in June, as exhibited in the July minimum of admissions, and this may be ascribed so far as the host, *per se*, is concerned, partly to the exhaustion of the most susceptible personnel, and partly to the departure of the younger men and of convalescents, from attacks in April and May, to the Hills, whence they return, as a rule, in July after the establishment of the monsoon. Furthermore, it must be concluded that contact infection as a chief means of propagation, operates under the most favourable conditions, only on the concurrence of several fortuitous circumstances, one or more of which must frequently be wanting in cantonments where the barracks are spread over a wide area. The remarkable fact that only a minority of the men who may be regarded as susceptible acquire the disease, may, therefore, be taken as supporting, in a general way, the more direct evidence of the predominance of this means of infection. So large a majority at the most susceptible age and service periods would, it appears clear, not escape, if the chief source of infection depended on some common agency in general operation. The most susceptible individuals are scattered in the smaller company communities among the more resistant and immune, and it must frequently result that the necessary co-operating factors for contact infection are wanting wholly or in part, and hence the capricious and selective character of the incidence.

We may now proceed to a brief examination of the records of the prevalence of Enteric Fever among the European officers, women and children, and we shall give, in the first place, a comparative statement of the incidence on these different classes and on the rank and file of the army during the last three complete decades and the subsequent period to date.

TABLE XLIII.

Enteric Fever among the Rank and File, and the Officers, Women and Children of the European Army in India,
1871-1900, 1901-1904.

Period.	Ratios per mille of strength.							
	Rank and File.		Officers.		Women.		Children.	
	Ad.	D.	Ad.	D.	Ad.	D.	Ad.	D.
1871-1880	5·1	2·23	—(*a*)	1·33	1·8	0·89	1·0	0·21
1881-1890	13·2	3·81	—(*a*)	3·08	5·1	1·37	2·3	0·43
1891-1900	24·2	6·46	32·7 (*b*)	5·54	7·3	2·33	4·5	0·64
1901-1904	17·4	3·89	23·3	4·01	8·1	2·11	5·6	0·51

(*a*) Not available. (*b*) For period 1895-1900 only.

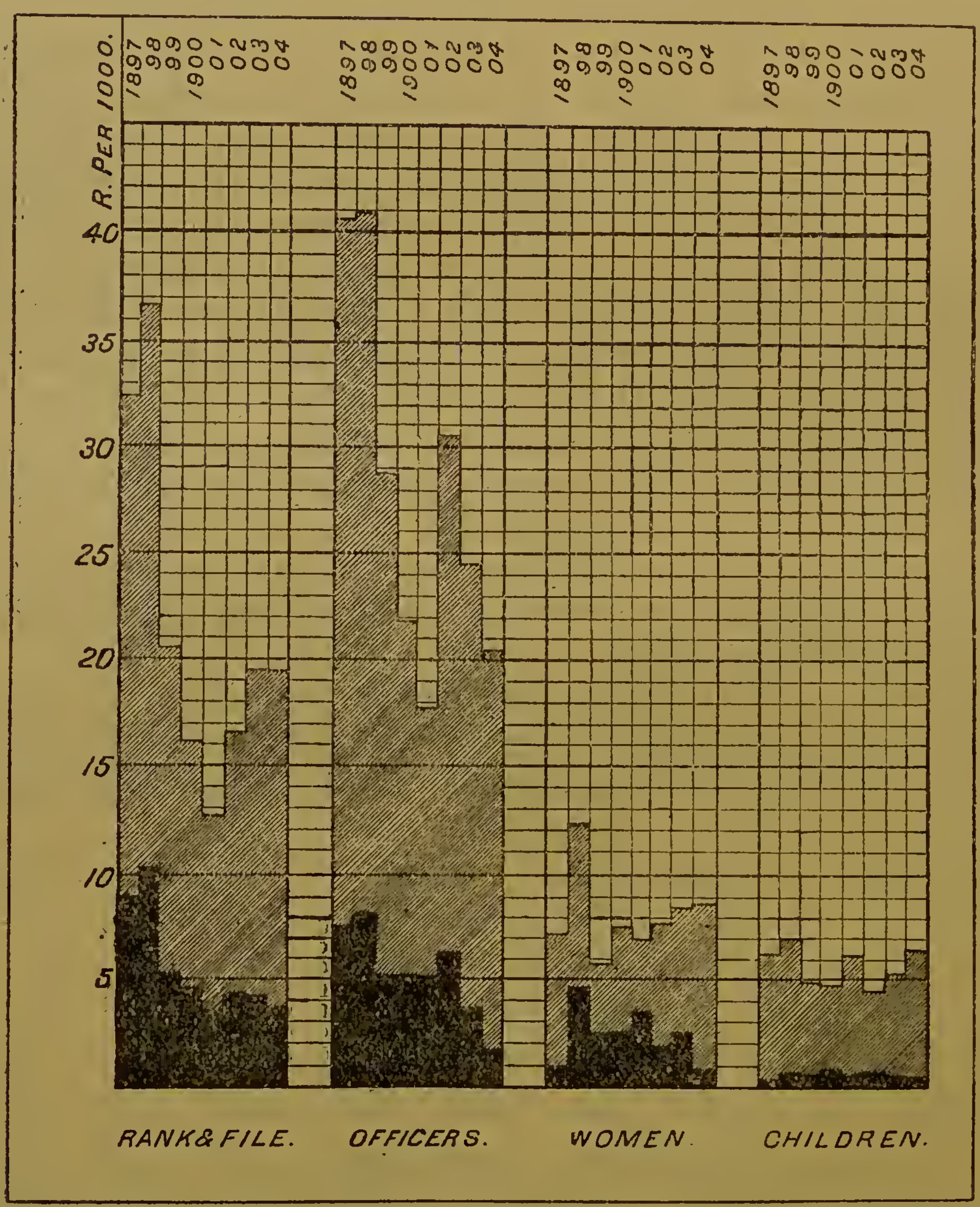
With certain remarkable variations in the extent of the incidence, such as would be anticipated, there is also a very general similarity in the course, rise and (in the last four-year period) decline of the disease among all the classes. If the first decade be compared with the third (the period of greatest prevalence) it will be found that the extent of the rise in the recognized cases follows a fairly equal ratio throughout, and the same may be said generally of the recorded mortality, though the case of the officers in this respect is more serious than that of the other classes and notably than that of the women. Again, taking the decade 1891-1900 as most fairly representative, we find the case-mortality exhibiting great variations: for the women it is as high as 32 *per cent*, for the rank and file 26·6, for officers 17, and for children just over 14 *per cent.* There are, of course obvious reasons for this contrast, in the different age constitutions of the several classes, and in regard to the officers, in the facts that they come under treatment at an earlier stage than is the case with the men, and that the conditions for treatment and nursing are certainly more favourable. Any further general discussion of the significance of the high case-mortality would be superfluous after what has been said on the subject in Chapter II., but the facts as to the course of the "other fevers" among the women and children will be stated in due course. Finally, the comparative table shows that the marked decline in the prevalence of the disease which is common to the records of officers and men in the most recent period, was not experienced by the women and children, and this is probably due to the fact that in these classes there was far less change in the age-constitution and in the term of residence in India, while all the other conditions of life remained unaltered.

But we should miss an important indication if we fail to distinguish between the course of the disease in recent separate years and that exhibited in the combined periods, thus:—

Enteric Fever.	Rank and File.		Officers.		Women.		Children.	
	Ad.	D.	Ad.	D.	Ad.	D.	Ad.	D.
1897	32·3	9·06	40·5	7·7	7·1	0·93	6·2	0·34
1898	36·8	10·17	40·9	8·03	12·2	4·81	7·0	0·54
1899	20·5	5·14	28·8	5·24	5·8	2·26	4·9	0·36
1900	16·01	4·77	21·9	5·06	7·6	2·41	4·7	0·74
1901	12·8	3·32	17·8	5·00	7·0	3·30	6·1	0·59
1902	16·7	4·29	30·6	6·21	7·8	1·96	4·5	0·64
1903	19·6	4·19	24·7	3·65	8·6	2·42	5·3	0·43
1904	19·6	3·76	20·3	1·72	8·7	0·93	6·4	0·40

The outstanding features of the course are a rise to the culminating point in 1898, followed by a decline during the next two years (one only in the case of the women) with a subsequent gradual upward trend, the highest point of which, so far, is well below the previous maximum; these features are common to the records of all the classes in a remarkable degree, and this will be rendered clearer if the data are given in the form of a diagram.

CHART No. XXI.



ENTERIC FEVER: AD AND D. PER 1000 OF STR 1897–04.

ADMISSIONS = ▨ *DEATHS* = ■

These facts need little comment; during the two trooping seasons of 1899-1900 and 1900-1901, we know that the supply of reliefs and of drafts to the rank and file was almost suspended, and at the same time the numbers of women and children arriving in India were also greatly diminished, but not to the same relative extent; there is no exact record of the movements of the officers, but it is known that fewer came to India during the period in question; their average strength fell from about 2,000 in 1898 to 1800 in 1901, and ordinary leave was practically closed. We have, therefore, similar changes in the personnel exposed in the period of decline as regards all the classes—a decrease in the numbers of new-comers and a higher age-constitution of those in the country; but these changes affected the rank and file in the greatest degree, with corresponding results in the incidence of the disease. Beyond this, the facts as a whole appear to indicate some definite and more or less intimate relation between the extent of the infection among the rank and file and that in the other classes, when we consider the different conditions under which they live, together with the one salient fact of common intercourse which only varies in degree: it is difficult to understand the results on the hypothesis of the omnipresence of infection outside cantonment limits.

It may further be noted, as a point of general interest bearing on the course of the disease among the rank and file and the women that the proportion of married men in the army in India has steadily fallen from 11·3 *per cent* of the total force exposed in 1872 to 3·29 *per cent* in 1893, when the returns (as to marriage) were abolished. During the last thirty years or so the average strength of the women has been reduced to one half, while that of the rank and file has increased but slightly, and, consequently, in the absence of specific data on the point, it may be concluded that there has been, in recent years, a larger proportion of unmarried women included in the class than was formerly the case.

We may now touch briefly on some of the more striking characteristics of the record of Enteric Fever for each class separately, and, first as regards officers with British troops we have to note the excessive liability to attack which they exhibit in comparison with the rank and file. This has already been indicated in the foregoing statements, but we may add to these an analysis of the distribution of the incidence on the several Commands and on India as a whole, the figures representing ratios *per mille* of strength for the combined period 1895–1903.

TABLE XLIV.

Enteric Fever. Incidence on Officers and Rank and File by Commands and for all India 1895—1903.

	Officers.		Men.	
	Ad.	D.	Ad.	D.
Punjab	33·9	5·77	27·9	7·62
Bengal	28·8	5·17	25·8	6·33
Bombay	27·5	6·29	22·2	5·80
Madras	20·0	5·00	12·4	3·13
INDIA	30·0	5·02	23·3	6·06

Beyond the fact of the excessive liability to attack to which officers are clearly subject in all the main geographical areas, it will be seen that there is a striking conformity in the *relative* order of the incidence on both classes, and this conformity may also be traced in the *relative* incidence in the different areas, when due regard is paid to the comparatively small numbers of officers exposed in the Bombay and Madras Commands, and to the greater fluctuations in the rates from year to year, thereby involved.

To what causes is this excessive liability of officers to be traced? If, in the first place, we look to the age-factor, we find ourselves at a loss to account for it, for an analysis of the army list shows conclusively that not more than 38 *per cent* of the total cadre comes within the limit of the age period of 25 years and under,* that is to say that the proportion at the most susceptible ages is only about two-thirds of that in the rank and file; while no claim is made for the absolute exactitude of these proportions in the case of officers, owing to the difficulties attending the extraction of the data, the age contrast with the rank and file is so pronounced as to leave a very liberal margin for error, and to establish the main conclusion. It is difficult to ascertain the precise facts as to the proportion of new arrivals disembarking annually, but it must be concluded that in this respect the officers are at little disadvantage in comparison with the men. In 1903 and 1904 the number of officers arriving in India by the troopships was equal to about

* The ages of all the officers in the 56 corps (Cavalry and Infantry) present in India in the last quarter of 1904 were verified; total number of officers 1896, of whom 720 were under 25 years of age.

·25 *per cent* of the total strength exposed in those years, which is about the average, as a rule, for the rank and file.* We see however that officers are liable to attack in a definite and corresponding ratio to the extent of the infection among the men with whom they are brought into contact, and we are thrown back upon the suggestion that, sources of infection being present, the excessive liability of the former must be due to certain broad biological causes affecting the officers' powers of resistance to the infection, and possibly also to some contrast in the life habits in the two classes tending to the same result. It is an established fact that the well-to-do and better-nurtured classes of the population in civil life in Europe are especially prone to attack by Enteric Fever; this fact, indeed, served to establish the distinction between this disease and Typhus in the early days of their confusion as a single pathological entity. With the progress of domestic hygiene and the steadily increasing contrast in the conditions of life to which the upper and lower classes of the population in Great Britain have been subject during the past century and a half, there has been ample scope for the operation of the forces that tend to produce different degrees of reaction—of resistance or of susceptibility—to the same stimuli under contrasted conditions of experience thereof. We may reasonably date the commencement of this contrast from the middle of the 18th century and the rise of the industrial revolution—which has resulted in a great increase of wealth, the benefits of which have been enjoyed, in largest measure, by the minority (the classes from which our officers are drawn), while there has been comparatively little mitigation of the lot of the masses who have been driven in ever-increasing proportion into the large urban centres. Experience of a filth-disease before the sanitary era which set in a hundred years later, must surely have been very different in the two broadly-contrasted classes, the rich and the poor, and as Enteric Fever attacks by preference the young before the age of marriage, we should expect the most susceptible to be eliminated to a far greater extent among those whose life conditions provided this experience to its fullest degree. With the general progress of public sanitary measures we may also expect a gradual loss of the relative immunity acquired by the poorer classes, and this may explain, in part at least, the notable

* The term of service of officers is of course longer than that of the men, and the former obtain leave to England to a liberal extent.

increase in the prevalence of the disease among the rank and file during the last 30 years when exposed to an alien environment in which the infection is rife. It must also be remembered that service in the ranks is too frequently the resort of the poorest and most destitute, while the officers are drawn, as a rule, from the opposite end of the social and economic scale. We have also to recognize the fact of a class immunity, which is merely that acquired by the component individuals in aggregation, and is due to the gradual interaction of the organism and the environment (including in this the specific bacillus); the older residents of a locality are less liable to react pathologically to the infection than new-comers. This personally acquired immunity is doubtless only one of degree and more or less special to the locality, but it may be assumed that it confers relative powers of resistance when such individuals are exposed to risk elsewhere and under more trying conditions.

These considerations, abstract as they may appear, are entitled to the greatest weight, when due regard is paid to the importance of the factor of individual predisposition as shown by the selective operation of the infection in the immunity enjoyed by the majority at the most susceptible ages, and in the effects of fatigue and exposure.

Again, as regards personal habits, it is not impossible that the dietetic customs of the two classes operating through generations have produced modifications in the structure and function of the intestinal tract that render it more or less susceptible to predisposing derangements under the stress of an alien environment, in view of the delicately adjusted organic equilibrium of all the organs and faculties. It is probable that while much remains to be desired in the matter and manner of the arrangements for the feeding of the soldier in the ranks, he is at an advantage in this respect on entering the service as compared with the officer, when their previous experiences are taken into account. It may be noted that the officers as a body suffer more from other specific bowel complaints than the rank and file;* during the period 1895—1903 the mean admission rate from dysentery was 30·3 *per mille* for the former against 27·6 for the latter, and indeed the extent of the sickness on this account follows the same order as that from Enteric Fever in all the four classes now under consideration, which may be

* It is a striking fact that the sickness and mortality from Cholera has always been higher among officers than among the rank and file; in 1895—1900 the mean admission and death-rates were 1·2 and ·9 for the former against ·9 and ·6 *per mille* respectively for the latter.

taken in support of the connotation of a varying predisposition ; the facts as to the incidence of "other fevers" given later, are also pertinent in this connexion. The officers of a regiment form a very small community, and there are circumstances leading to closer aggregation and common resort of the most susceptible individuals, at any rate as regards messing and, to a less extent, as regards housing. The more senior men are generally married and maintain separate domestic establishments, the subalterns often live together and the proportion of individuals at the most susceptible age in an ordinary regimental mess is very high and subject to constant fluctuations and reinforcements owing to social habits and to frequent movements and transfers. The association of the subaltern with the rank and file has tended to become more and more intimate in recent years in regard both to their common duties and recreations. Several individuals may thus be exposed to risk from numerous *foci* of infection and then meet together in a common resort ; the risks are thereby multiplied, though the force of each may be less direct than in the case of the rank and file exposed. For the rest, while the officer has more liberty, is more frequently moving from station to station and beyond the limits of the cantonment for purposes of sport, etc., and is probably more subject to the influences of fatigue and exposure in peace, he is in far less intimate and direct contact with the native in bazaars and with the real and supposed dangers connoted thereby. The officer again would appear to secure an important advantage in the system of the use of the separate commode attached to his bath-room with the prompt removal of excreta, in place of resort to a large latrine in common use ; it is probable that this advantage is often discounted by the indirect connexion with the latrine maintained by the sweeper, who is too frequently allowed by the other servants to take part in other domestic arrangements—the making of beds and even the preparation of food. The arrangements for lavatory purposes (including urinals) in many messes must also be a source of special danger.

An interesting fact that has frequently been commented on is the contrast in the liability to Enteric Fever exhibited by officers of the British service when compared with that of their confrères of the Staff Corps (Native army). There is no record of the number of attacks in the latter class, but their mean death-rate from this cause for the combined period 1895-1903 is a little less than one-third of that of the former, 1·97 *per mille* against 6·02. This result was, obviously, to be anticipated on all the etiological considerations. The proportion of the total strength of officers of the Indian Army under 25 years of age is, so far as can be deduced from the data available, only about 22 *per cent* (against 38 *per cent* for their confrères), and as they invariably join a British regiment on entering the Service and serve a period of probation therein before passing on to the Staff Corps, the risks to which they are exposed are not comparable with those incurred in the other branch of the service. They are thus at a very decided advantage in regard to the two all-important predisposing factors, age and first experience of the environment; the most critical period of risk, the first 18 months or so, being passed with European troops, during which time many of the most susceptible are eliminated by attack. Beyond this, a larger proportion of Staff Corps officers are married and maintain separate establishments, and there can be little doubt of the fact that their messes are under better control in regard to all the risks of infection from outside. On the other hand they are in closer contact with natives, who are still less scrupulous in their habits with regard to the disposal of their excreta than their European comrades, and if Enteric Fever were at all common among the sepoys or their families the results would be more strikingly demonstrated in the experience of their officers.

In view of the association of the officers of the two Services, the one recruiting its staff from the other, their frequent service in the same stations in adjoining cantonments and their social intercourse, we might expect to find a similarity in the general course of the incidence of Enteric Fever on the two cadres, and this is to some extent the case. The death-rates may be compared for the last ten years of the record:—

TABLE XLV.

Enteric Fever Mortality among Officers of the European and Native Armies, 1894-1903.

	Ratios per mille of strength.									
	1894.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.
Officers—European Army ...	5·75	6·72	6·31	9·01	10·17	5·14	4·77	3·32	4·29	4·19
Officers—Native Army ...	1·59	1·88	1·89	2·62	2·42	1·34	1·20	1·30	3·67	1·79

The salient features of this comparison are the sudden rise in 1897-1898 with the subsequent decline, due to causes operating commonly on both classes, *viz.*, active service on the Frontier (Tirah campaign); and secondly, the diminished supply of officers to India consequent on the exigencies of the Boer war. In other respects there is some indication of a common source of infection, though it be less marked than that displayed in the chart showing the incidence on the British rank and file and their officers ; and here again, we may reasonably conclude that the one paramount determining factor influencing the course of the disease is the more or less close association with the European troops. This is brought out when the circumstances of this association are abnormal ; an instance has been given in regard to the results in 1897-98 when both branches were on active service together (Tirah). The exceptionally heavy incidence on Staff Corps officers in 1902 is to be attributed to the excessive number of recruits who joined in that year ; in 1900 there were only 88 ; in the first 10½ months of 1901 there were 101, whereas from the middle of October, 1901, till the end of 1902, the number rose to 231.

Lastly, it must be noted that the local incidence of the disease in the case of officers is very definitely associated with the areas and stations in which the rank and file suffer to the greatest degree, *viz.*, the larger cantonments in the endemic area and the hill stations. As regards the former it is clear that there are abundant sources of infection, and that there are larger numbers of susceptible individuals in close aggregation and constant association ; as regards the latter, while similar circumstances prevail to a certain extent, there is obviously even less ground for invoking native sources of infection *en route* than in the case of the rank and file (see Chapter V.), for officers do not as a rule march up to the hills, but perform the journey in a few hours by the ordinary means of conveyance. We must then look again to importation from plains stations and to local sources of infection to explain the record from the hills, which places these health-resorts at the head of the list. It is not affirmed that infection is never contracted *en route*, for there is good ground for the condemnation (and reform) of the existing arrangements at railway refreshment rooms and at staging bungalows ; it is, however, maintained that there is little need to seek for extraordinary and occasional sources of infection when these are known to be abundant within cantonments in the plains and hills alike.

and, moreover, we cannot evade the probability of infection outside cantonments being derived from the troops or the officers themselves.

It is desirable to supplement this account with a statement of the incidence of Remittent and Simple Continued Fevers on the rank and file and officers, respectively, in the different Commands.

TABLE XLVI.

Remittent and Simple Continued Fevers among Officers and Men by Commands. Mean ratios per mile, 1895-1903.

	Remittent Fever.				Simple Continued Fever.			
	Officers.		Men.		Officers.		Men.	
	Ad.	D.	Ad.	D.	Ad.	D.	Ad.	D.
Punjab	50·6	·46	22·3	·45	36·7	...	22·7	·02
Bombay	27·3	·23	7·9	·21	58·0	...	26·4	·07
Madras	27·2	·94	10·5	·22	82·5	...	34·6	·01
Bengal	21·6	*Nil.*	10·7	·15	44·8	...	30·1	·01
India	33·5	·34	14·0	·28	53·0	...	28·0	·03

The liability of officers to these anomalous forms of fever is seen to be far greater than that of the rank and file, a fact of some significance in the light of the excessive incidence of Enteric Fever on the former class. Remittent Fever is highest and Simple Continued Fever at its lowest in both classes in the Punjab, where also the Enteric rates are at the maximum, but any suggestion of a relation, direct or inverse, that might be conveyed by these data has to encounter the facts as recorded for Bengal, which occupies a place along with the Punjab as regards Enteric and Simple Continued Fevers, but is at the opposite end of the scale for Remittent. Elsewhere the Simple Continued rates are notably highest where Enteric is least prevalent. It would be an idle exercise to endeavour to thread the maze of these indications in the present state of our ignorance of the pathological connotations of so-called Remittent and Simple Continued Fevers; we cannot, therefore, appraise the varying extent of diagnostic error, while it is certain that the pathological entities included under these terms vary in character and in extent in the different areas. We may at least draw the broad deduction that officers are everywhere in India much more prone to suffer from forms of fever under which true Enteric is often obscured, and which in other cases may be held to predispose to, *or develop into*, this infection.

We have already discussed briefly the main facts of the position as regards the women of the European army, both as to the actual recorded incidence of the disease and the relation it bears to that falling on the other classes (see Tables pp. 306-307). We may supplement this with a statement of the relative prevalence in the different Command areas which may be compared with that relating to officers and men on page 310.

TABLE XLVII.

Enteric Fever among Women by Commands.

Mean ratios per mille, 1895-1903.

	Ad.	D.
Punjab	11·4	3·71
Bengal	9·4	2·66
Bombay	7·5	2·34
Madras	4·0	1·90
INDIA	8·3	2·67

This is in striking conformity with the results recorded for the other classes, and when taken with the other evidence, tends to support the contention of the dependence on association, the infection in one section of the community bearing a distinct relation in place and time to that in the others, the extent of the prevalence being controlled by the etiological factors common to all sections, or prevailing in each in varying degree. As regards this relative extent in the case of the women, there are all the indications of the operation of factors previously invoked; there are no records of the age-constitution of this class, but we know that the majority are wives, and it may be assumed with some certainty that the largest proportion are included in the 25 to 30 age-period, and if this be so, the Enteric Fever rates differ only in a degree which is explicable from those recorded for the men at the same ages. This diminishes the obscurity which has been imported into the discussion on the ground of a supposed relative immunity of the women as compared with the men, and on which theories have been based to account for infection apart from the use of polluted drinking-water. It has been said that as water-supplies are in common use by both the men and the women, and as women consume much more water and yet suffer, *ex hypothesi*, far less from the disease, therefore water-borne infection must be relatively rare. It would be contrary to most of the indications if it could be proved that the women do indeed escape their due proportionate liability, but the evidence does not afford support to this conclusion. The relative protection afforded by a higher age-constitution is reinforced, to some extent, by the relatively diminished proportion of new arrivals ; it would appear that a number equal to only about one-sixth to one-fifth of the average strength exposed is disembarked annually, against about one-fourth in the case of the rank and file and officers ; this connotes a longer average residence in the country, their careers therein being associated with those of the older men. This fact, again, might be expected to involve diminished risk of infection to the women, the children with whom they are in closest contact being apparently still less liable to the disease than the men as a body ; the striking conformity in the course of the rates recorded among the women and children, respectively, will have been obvious from the class statements already given. And as regards the steady rise in the rates we have merely to refer to the increased prevalence of the infection in the immediate environment as the chief factor, though doubtless more accurate diagnosis has contributed to the result ; and the effect of some lowering of the age-constitution in recent years cannot be excluded. This increased prevalence has an important bearing on the question of the true chief sources of infection in all the classes under consideration ; we cannot invoke any marked change in this respect during the last 30 years in the extra-cantonment (native) environment, nor any radical alteration in the character of the personnel of the women and the officers and children as classes, such as must be admitted in the case of the rank and file, and yet the disease exhibits a strikingly proportionate increase in all four sections of the community, and this with a definite relation to locality which is common to all. It is submitted that after all possible deduction is made for improvement in diagnosis, a factor which operates fairly equally as regards all the classes, the one essential feature of the situation disclosed is the increased prevalence of the infection *within* the community of the army as a whole, and consequently the component classes in association exhibit the same results, modified of course in each case by the etiological factors special to each. The history of the disease—the incidence in time and place—and its extent is, in all essential respects, the same in all the classes ; we cannot explain the phenomena in one without reference to one or more of the others ; and we must regard the main body of the rank and file as having the widest relations and as doubtless providing the main source of infection, as well as the epidemiological connexion and the key to the concerted results. It is almost impossible to conceive this striking adjustment as the result of more or less fortuitous contact with sources of infection outside the community itself, the different classes having such markedly contrasted relations therewith, both in kind and in extent; this is, indeed, the main contention which a study of the disease in each class separately goes far to justify, but which derives its greatest force from the consideration of the records in combination and of the relations subsisting between the classes in association.

It is unnecessary to dwell at further length on the special conditions of life to which the women are subject as contrasted with those of the rank and file: the former, doubtless, escape certain risks by avoiding direct contact with common latrines owing to the use of separate commodes in their quarters ; they must be also less subject to the influences of fatigue and exposure (as from field service, marches, manœuvres, etc.) and to the risks involved in common messes, and in other conditions attending aggregation and resort in common (native bazars, etc.). The diminution of the average strength, which amounts to about 50 *per cent* during the last 30 years, has been an important factor in promoting amelioration in all the conditions affecting the health of the women, notably by increasing the accommodation available and consequently diminishing aggregation and contact which subserve the propagation of all infections. No class in the army has responded more satisfactorily to all the efforts made to improve the sanitary and general conditions of life in cantonments, of which the course of the death-rates from fevers and bowel-complaints afford ample testimony. Comparing the results for the men and women, respectively, we get the following death-rates *per mille*, in the last three decades :—

	Rank and File.				Women.			
	Cholera.	Dysentery and Diarrhœa.	Enteric Fever.	Other Fevers.	Cholera.	Dysentery and Diarrhœa.	Enteric Fever.	Other Fevers.
1871-1880	2·8	1·7	2·1	1·28	3·46	3·5	·89	3·3
1881-1890	1·46	·89	3·81	·70	1·70	1·73	1·37	1·51
1891-1900	1·06	·94	6·46	·74	·96	·96	2·33	1·07

It will be seen that whereas the combined mortality from all the above causes among the rank and file rose from 7·88 in the first period to 9·2 in the third, it fell in the case of the women from 11·15 to 5·32; the combined fever rate (Enteric *plus* "other fevers") rose in the one case from 3·38 to 7·2, while it fell in the other class from 4·1 to 3·4. This might lead to the conclusion that there has been no true rise in the incidence of Enteric Fever among the women, but the facts are, indeed, against that assumption; there is the notable decrease in the rates under all the other heads, and a study of the old Reports leaves no doubt of the excessive prevalence in the pre-sanitary era of fatal forms of fever of the malignant malarial type which are now far less in evidence. But the best indication is derived from the *course* of the mortality rates from fevers through the decades, thus :—

	Enteric Fever.	Other fevers, S. C. and Remittent.	Combined Rate.
1871-1880 ...	·89	3·3	4·19
1881-1890 ...	1·37	1·51	2·88
1891-1900 ...	2·33	1·07	3·40
1901-1904 ...	2·11	0·70	2·81

We must either repudiate the evidence in favour of the occurrence of other fatal forms of fever, which is impossible, or acknowledge that the sanitary and other measures of amelioration, which were inaugurated about the end of the first decade, operated to diminish the more purely tropical infections (bowel complaints and "other fevers"), while leaving Enteric to claim an ever-increasing number of victims, though, doubtless sanitary measures have controlled, to some degree, the fuller extent of this increase. The course of events has been the same in the case of the rank and file and the other classes; Enteric Fever has increased in much the same ratio in all the associated classes, and it is only in regard to the actual extent of the increase, and its relation to other fevers, that apparent contrasts are exhibited.

Lastly, the case of the Children claims brief notice. Table XLIII. brings out the facts of the course and rise of the disease during the last 35 years and the striking conformity in these respects to the order and extent of the phenomena exhibited in the other classes. As regards the local distribution of the incidence, the now familiar features recur with insignificant variation.

TABLE XLVIII.

Enteric Fever among Children of the European Army by Commands.

Mean ratios per mille, 1895-1903.

	Ad.	D.
Punjab	6·5	·52
Bengal	5·6	·50
Bombay	6·3	·35
Madras	3·9	·82
INDIA	5·6	·54

The indications have been sufficiently emphasized in the previous discussion, and we may at once pass on to a statement of the facts as regards the "other fevers" which derive a special importance in the case of children on account of the widely prevalent opinion that much true Enteric is included under these heads. We may take the period 1895-1903 as adequately representative and as furnishing the most accurate returns, and trace the course of the three classes of fevers and the combined results (see next page).

As regards the Enteric Fever record, the course of the rates to the culmination in 1898, and the subsequent decline have already been discussed in connexion with the same phenomena in the other classes. A striking feature of the statement is the abrupt fall in the rates from Remittent and Simple Continued

TABLE XLIX.

Enteric, Remittent and Simple Continued Fevers among European Children of the Army in India as a whole.

Annual ratios per mille of strength, 1895-1903.

	Enteric Fever.		Remittent Fever.		S. C. Fever.		Combined Rate.	
	Ad.	D.	Ad.	D.	Ad.	D.	Ad.	D.
1895	5·1	·35	11·4	2·63	26·7	·35	43·2	3·33
1896	6·4	·86	9·7	1·73	28·0	·69	44·1	3·28
1897	6·3	·35	13·2	1·22	21·6	·87	41·1	2·44
1898	7·0	·54	8·4	1·43	32·4	1·07	47·8	3·04
1899	4·9	·36	7·5	·36	18·0	·55	30·4	1·27
1900	4·7	·74	10·4	1·49	18·2	...	33·3	2·23
1901	6·1	·59	5·5	·59	8·7	...	20·3	1·18
1902	4·5	·64	3·0	·64	11·0	·21	18·5	1·49
1903	5·3	·43	1·5	...	10·9	...	17·7	·43
Mean Rate for period .	5·6	·54	8·1	1·16	20·0	·44	33·7	2·14
Case Mortality *per cent.*	9·6		14·3		2·2		6·3	

Fevers in 1901 and the following years, the means for the last triennium being less than half of those for the previous six years. In view of the considerable rise in the Enteric rate in 1901, one is tempted to suggest that here we merely see the results of a change in nomenclature, and as an element of uncertainty is constantly imported into the discussion on this account, it is desirable to examine the position in closer detail. Now, it will be found that the same marked diminution in these anomalous forms of fever occurs to a fairly equal extent in all the Commands, in spite of the fact that their relative incidence on the different areas is in strong contrast, thus:—

Enteric, Simple Continued and Remittent Fevers among Children by Commands, in order of prevalence.

Mean ratios per mille, 1895-1903.

Enteric Fever.			S. C. Fever.			Remittent Fever.		
	Ad.	D.		Ad.	D.		Ad.	D.
Punjab ...	6·5	·52	Madras ...	39·0	·73	Bombay ...	9·5	1·91
Bombay ...	6·3	·35	Bengal ...	18·8	·14	Punjab ...	8·5	1·29
Bengal ...	5·6	·50	Bombay ...	12·5	·52	Madras ...	7·5	·37
Madras ..	3·9	·82	Punjab ...	11·0	·43	Bengal ...	7·0	1·07
INDIA ..	5·6	·54	INDIA ...	20·0	·44	INDIA ...	8·1	1·16

These contrasts in the incidence under different local conditions may be explained on the assumption that the nosological terms connote different pathological entities ; but it will be noticed that the order of prevalence of Simple Continued Fever bears an inverse relation to that of Enteric, while that of Remittent is more or less direct. It is possible to recognize in these facts a suggestion of some underlying pathological unity, the contrasts of incidence arising from a loose and varying interpretation of the clinical signs, *e.g.*, the course of the temperature, as to which no two observers may be found to agree ; both an inverse and a direct relation in the local incidence may then be regarded as supporting the above suggestion with equal force. We may next analyse the death-rates (1895-1903) and the case-mortality for any indications they afford.

		Enteric Fever.	S. C. Fever.	Remittent.	Combined.
Bombay ...	Death-rate ...	·35	·52	1·91	2·78
	Case-Mortality % ...	5·5	4·1	20	9·8
Punjab ...	Death-rate ...	·52	·43	1·29	2·24
	Case-Mortality % ...	8	4·0	15·2	8·6
Bengal ...	Death-rate ..	·50	·52	1·07	1·71
	Case-Mortality % ...	9	0·7	15·2	5·4
Madras ...	Death-rate ..	·82	·73	·37	1·92
	Case-Mortality % ...	21	1·8	5·0	3·8

It will be seen that the combined death-rates from Simple Continued and Remittent Fevers follow an order which is inverse to that exhibited by Enteric in the different Commands, and further that the same result appears in the relative order of the case-mortality, thus :—

	Case-Mortality, Enteric Fever.	Case-Mortality S. C. & Remittent combined.
Bombay	5·5	10·6
Punjab	8·0	8·8
Bengal	9·0	4·6
Madras	21·0	2·3

It must be noted that the extreme contrast shown in the records for Madras and Bombay, both geographically in the peninsular area, is probably due to the fact that the great majority of the children in the latter Command are located in the few larger stations which come into our endemic area.

The inverse relation thus displayed certainly appears to be significant of the difference of interpretation to which the same forms of fever are subject in the several areas, even if we allow that the non-Enteric Fevers vary greatly in the extent of their prevalence and in their fatality in these areas. This is shown to be the case by the records not only of the European rank and file but of the Native troops and prisoners, the relative prevalence and the case-mortality from the "other fevers" in all these different communities being remarkably similar in their local incidence. If, further, we now examine the incidence of the mortality on the different age-periods, the evidence, so far as it is reliable, would appear to suggest a clear pathological distinction between Enteric and the other fevers and the common bowel complaints.

TABLE L.

Mortality of Children by Ages from Enteric and Other Fevers and Bowel Complaints.

Mean ratios per mille, 1893-1903.

Ages.	Strengths.	Enteric Fever.	Intermittent Fever.	Remittent.	S. C. Fever.	Dysentery.	Diarrhœa.
Under 6 months	3,859	·26	6·2	3·8	2·6	2·8	38·0
From 6—12 "	4,748	·42	4·2	3·7	1·8	7·5	21·4
" 12—18 "	4,490	·22	2·6	1·5	·44	4·4	13·6
" 18—24 "	4,683	...	1·06	1·06	...	2·1	2·8
" 2—5 years	17,535	·51	·85	·90	·05	·9	·8
" 5—10 "	17,670	·73	·39	·45	·05	·3	·17
" 10—15 "	6,779	1·03	·14	·59	...	·14	...

In the one case (Enteric) the rates rise steadily with each age-increment, in all the others they fall with equal consistency: and further, the contrasted incidence has a special significance when the respective case-mortalities are borne in mind. Out of a total of 34 fatal cases of Enteric recorded in the period, 30 occurred among children of two years of age and upwards, whereas two-thirds of the mortality from the "other fevers" fell upon infants of less than two years of age. Now, while the case-mortality of the former, which has been seen to be at the rate of 9·6 *per cent*, may be regarded as fairly consonant with universal experience elsewhere for the age-periods shown to be mainly affected (though higher than the European standard as is to be expected), the case-mortality of Remittent Fever (*viz.*, 14·3 *per cent* all round)* is certainly indicative of a distinctive and more fatal pathological process. For it must be even higher than 14·3 *per cent* on the two-thirds of the cases occurring among the infants of less than two years of age, and it is totally contrary to experience to find Enteric proving fatal in, say, about one-fifth of the attacks at this age, when indeed, the case-mortality is known to be insignificant. The facts as regards Simple Continued Fever, are, however, certainly more suggestive of some relation, though even here far from conclusive, and when we see the mortality from Intermittent Fever following precisely the same course, the sum of the evidence, finally appears to point to the agency of Malarial infections of varying malignancy as affecting the infants, to the exclusion of true Enteric; and this view receives support on more general grounds of experience of the relative susceptibility of infants to the two diseases, which, indeed, could only be expected in view of the very different experiences of the race in regard to them.

We were led to this discussion by observing the sudden fall in the rates from the anomalous fevers that took place in 1901 and which has since been maintained, and when we look beyond the children and examine the records of the other totally distinct communities under medical supervision, precisely the same phenomenon is clearly elucidated, *viz.*, in the other classes of the European army, in the native army and in the prisoners.

Apart from the question of the different liability of each of these several communities to the same diseases, we cannot refer the phenomenon altogether to a common and simultaneous change in the diagnostic idiosyncrasies of the medical officers in charge of these different bodies, for these officers are for the most part isolated and distributed over an enormous area; they have little or no communion and are not under one administration. It must, therefore, be concluded that in the so-called Simple Continued and Remittent Fevers we are dealing with pathological states that, while they may include an indefinite amount of true Enteric, are for the most part etiologically

* The case-mortality of dysentery is identical.

distinct from that disease; and, further, that we must look to some general agency which operated to diminish the former, while leaving the latter unaffected, in 1901 and the subsequent years. It is possible that a notable decrease in the prevalence of Malaria which has marked the first years of the new century has had much to do in effecting the results in question, and the same remark applies to Influenza which was more or less rife in epidemic form, throughout the previous decade. It suffices, for our object, to show that there is danger in the too facile assumption, born of a reaction of opinion, of the identity of the majority of cases of these other forms of fever with true Enteric, and we have taken the opportunity of bringing the question to the test in the case of the European children as to whom the assumption is most often and most definitely made. There is certainly an increasing tendency on the part of medical officers to attempt to diagnose intractable cases of fever under some more definite heading than that of "Remittent Fever," as also to exclude from the category of "Ague," ephemeral cases of fever where the hæmamœba cannot be found, and this will be reflected in the returns in higher rates on account of Enteric and Simple Continued Fevers at the expense of Remittent Fever and "Ague." We have seen that it is possible to trace some direct relation, between the Enteric and "other fever" rates, in their course from year to year; and the inverse relation exhibited in the general course over a series of years is certainly suggestive, but far from conclusive of a complete etiological connexion, when, as in the case of the rank and file, we regard the extent and proportion of the rise and fall respectively, and find that the latter does not nearly account for the former.

With the final Summary of the Etiology before him (see Chap. VIII) the reader will doubtless be able to reconcile the conflicting aspects of the evidence. For our own part we may affirm our conviction that while Enteric and the "other" fevers under review frequently represent entirely distinct pathological reactions, yet in a large but indefinite proportion of the latter we merely see the results of the different play of the same (or potentially the same) forces in action. Given the same pathogenetic stimulus, it may vary in virulence and in its "specific" quality, and the resistance it encounters must vary in each individual host. On this view, Simple Continued, Remittent, Paratyphoid and Enteric Fevers are often merely different manifestations of an essentially identical reaction.

CHAPTER VII.

SUMMARY OF THE EPIDEMIOLOGY.

Key to Summary :—

General definition of the epidemiological position and of the disease process :—conditions of prevalence : the host, the parasite, the environment :—"endemicity" and chief sources of infection :—"variability" of incidence on *personnel* and locality and in time :—the key to the epidemiological *facies* ; the period of incubation and of infection, the means and modes of dissemination, and the character of the *personnel* :—the epidemiological type ; "contact" *v.* infection from a common source :—intra- *v* extra-cantonment sources of infection :—influence of physical conditions as determining the incidence, local and seasonal, and the means of dissemination ; drought and rainfall, their *modus operandi* on and through the soil and water-supplies :—variations in clinical type :—complications and case-mortality :—comparative epidemiology of the Contagions, with illustrations :—the indications.

It is desirable to sum up the main conclusions to which the evidence adduced has led, as a preliminary to a statement of the practical indications they afford.

In general terms Enteric Fever may be classed among the contagious diseases, which are definitely associated with a stage of civilization involving aggregation in more or less stable communities, under conditions that have failed to secure the effective removal and disposal of the excremental products of life ; it takes its place with cholera, dysentery and diarrhœa, which, in the words of Simon, are "diseases of which the very essence is filth, and which depend on the extension of a putrefactive (infective) process from matters outside the body to matters inside the body" ("*Sanitary State of the People of England*"). It is marked by its special incidence on certain age-periods and on certain communities, and notably where young adults are aggregated under more or less suddenly altered conditions of environment with improvised and defective hygiene, *e.g.*, among immigrants to unreformed urban centres, among troops in camp, and in mining settlements, etc. It is, further, transported from place to place by infected individuals or bodies of men, and the growth of traffic, intra- and international, has favoured its dissemination.

Whilst it has been recognised as occurring in all parts of the habitable globe, there are certainly marked differences in the susceptibility of different races, and, at the same time, a definite association with certain localities where it is endemic. No latitude, no altitude occupied by men has been found to confer immunity, but within the same climatic sphere there are extreme contrasts in the incidence on different places at one time, as well as on the same places from year to year. No fact is, however, more definitely established than a definite relation to season (climate), and this especially in the endemic areas, but with characteristic variations in different latitudes. So far then, we note certain salient features of the epidemiology in relation to the human host, to place and to time, but that in regard to each there are important qualifications :—with unrestricted distribution, a marked preference for certain localities on which the incidence is very variable ; with no climatic restriction, a very definite seasonal incidence ; with the special liability of certain communities and age-periods, there is the immunity of the great majority at the most susceptible ages, and great contrasts in the prevalence of the disease in similarly constituted communities.

These considerations bring us to the statement of the terms of the proposition in which the disease process must be defined. We have to regard the human host, the specific parasite and the circumstances of time and place (the environment) and their inter-relations ; the point to grasp being that the disease-process is to be expressed as the function of the sum of all these constituent factors ; that the *cause* is prefigured in the varying structure and quality of the tissue-cells of the host, from which the energies we denote symptoms are liberated in response to the stimuli of the pathogenic germ-agent, under the influence of varying conditions of the environment, which operate on one or other or both, and further provide the means of access of the latter to the former. We may find a helpful analogy in the application of this principle in Johannes Müller's law of "The Specific Energy of the Senses", and, at the same time, an explanation of the wide range in the pathogenic results due to the varying reaction of tissue-cells and stimuli. The key must fit the lock, but it also requires adjustment and a due application of force (virulence), which, to be effective, will vary with the resistance offered.

We have already dealt with the respective rôles of these factors and need only summarise in briefest terms some of the main considerations. The human host must be regarded as the essential stage for the development and maintenance of the parasitic life-phase of the parasite; the prime and ultimate source of the infection and the chief vehicle and means of its dissemination. The majority of men at the soldier's age harbour the parasite or its near allies at one time or other and, probably in many cases, repeatedly, while only the minority display recognizable signs of its presence, and this, under stress of lowered resistance of the tissues or of enhanced virulence of the germ, or both. At least it may be estimated that in every body of soldiers of regimental strength, there may be present annually three or four more or less actively infected individuals as sources of infection within the corps, and from which the morbid sequence is maintained under favouring conditions :—unrecognized cases (it may be in the healthy) through light, aberrant, or ambulant cases to the typical process, but not necessarily in this order.

The full force of these considerations can only be appreciated when regard is paid to the nature and extent of the community at risk, to the conditions under which it is exposed and to the period and means of infection (viability of the germ within the body and in external nature). On these points we may note the high proportion of men at the most susceptible ages and of those exposed for the first time to a totally alien environment after a rapid transfer from the natural habitat and the abundant risks of infection *en route;* the influence of aggregation of separate companies in barracks and of various corps units in transport and in one cantonment, with enforced personal contact, direct or indirect, by means of common resorts which bear a direct relation to the means of infection—latrines, refectories and dormitories ; and the instability of the communities, both in regard to *personnel* and to local movements, with the constant influx of drafts at the most susceptible age, and the frequent intercourse with other bodies and other places. The influence of this aggregation, and instability of the *personnel*, and of traffic on the importation and dissemination of infection, depends on the viability of the germ within and on the body, and in personal effects, clothing, etc., and on the long and varying periods of incubation (including "latency") of infection, and on its dissemination in the excreta of the sick, of convalescents, of unrecognized cases and even of the apparently healthy ("bacillenträger"). Where, further, all the special conditions are exacerbated to the fullest extent, as in camps, campaigns and manœuvres, the disease is invariably most prevalent. Lastly, the effects of previous experience of the disease and of adjustment to the environment, "acclimatization," whether acquired in India or elsewhere, will operate to modify the results. All these points have received illustration in the course of the discussion of the incidence on the different classes of the general community, on the different arms, on the corps units and their component companies, as well as in the more preliminary study of the epidemiology.

As regards the parasite and the environment, it is unnecessary to repeat the facts and conclusions set forth at length in the statement of the etiology (Chapter III.) and their bearing on the local and seasonal incidence (Chapter IV.), but we must emphasize the position of the *bacillus typhosus* among the class of the almost purely parasitic contagia, though it is capable of maintaining an extra-corporeal existence for a comparatively short period. Saprophytic viability in the full sense, including effective propagation, may also occur under favourable conditions, and here the environment plays its part, but sooner or later it must secure a passage through the human host for the maintenance and renewal of its effective specific properties. So that, after all, we are constantly referred back to the host as the prime and ultimate source of infection and as the chief vehicle for propagation and dissemination, and the character and extent of an outbreak will depend on the nature of the community exposed—number of susceptible subjects, opportunities for contact, traffic and intercommunication. At the same time the conditions of the environment as favourable or unfavourable to the ectanthropic viability of the germ will provide more or less opportunity for re-infection by mediate contact, or for a more general infection from a common source—water and food supplies. Apart from the paramount considerations derived from the special age and service liability, the facts of the geographical and seasonal incidence are inexplicable on any view that excludes the host.

It is not difficult to see how the old "localist" view of the disease commanded, and still commands, abundant support, and the position could be defended with much greater force than that assumed in the case of Cholera, as to which the history of the course of opinion and knowledge is instructive in this connexion. In neither case is the view to be negatived without qualification ; nothing is better established than the fact of endemicity, but from the first the evidence in favour of a contagion from subject to subject has gained in force and extent, until now opinion is divided on the question of the relative influence of human host and locality in the epidemiology. As we have seen, these factors cannot be divorced from their mutual relations, and it is necessary to enforce this position, with perhaps wearisome iteration, both on account of the practical issues involved and because the conditions prevailing in India are generally held to be peculiar on the view that the infection is everywhere widespread in the environment outside cantonment limits. At various points in the discussion we have been able to adduce considerations that not only lend no support to this assumption, but which render it extremely difficult to reconcile it with the epidemiological facts ; and if the contrary proposition has still to be proved we can at least maintain that it is not only unnecessary to invoke this ubiquity of the infection among the native population, but that to take it for granted is to incur the danger of diversion from the true point of attack. It is not recognized that the disease when acquired outside cantonment limits may be, and often must be, the result of infection spread by the men themselves in the haunts to which so large a proportion of the most susceptible resort ; there is no valid reason why a brothel or eating-house in the bazaar, maintained for the soldier's use, should be exempt from the danger which, by common consent, attaches to a cantonment latrine or refectory. Moreover, the evidence relied on to support the view of infection from outside is purely exclusive, and agreeable to the prevalent theory of sanitary righteousness within cantonments which cannot be sustained ; endeavours to trace the sources of infection have, further, been frustrated by a most inadequate conception of the etiology. We are justified by a reference to the body of facts set forth in the foregoing pages in affirming that scarcely one prominent feature of the epidemiology requires the invocation of outside sources of infection, while, on the other hand, the various problems are at once elucidated when we regard the soldier and his immediate surroundings as the prime source and foci of the disease. We can only barely allude to the considerations derived from the discussion of the course and rise and temporary decline of Enteric Fever, with the opposite results in the case of other fevers and specific bowel complaints ; to the local and seasonal incidence ; to the evidence of importation into India and from one station to another ; to the history of camps and campaigns ; and to the incidence on corps units and their components as well as to the striking features of the course and prevalence of the disease among the different classes of the community in combination. "*Seu vetus est verum diligo sive novum*" ; there is, indeed, much in the old view which is true, but we must readjust our standpoint in regard to the whole body of evidence if we are to obtain the key to the more constant and salient phenomena, and, at the same time, to bring the apparent anomalies into line with the general plan. The test of anomalies should at least be deemed searching and fruitful in corroboration or refutation, and in this case it may be welcomed.

At the outset of this summary attention was drawn to certain important qualifications to which the broad features of the epidemiology are subject (page 328), and in referring to some of the more patent anomalies, we are only taking account of another salient feature, the characteristics of which it will be convenient to sum up under the term of *Variability of incidence*. This variability is demonstrated in regard to the *personnel* (host) and the parasite, and in their interaction ; and also in regard to locality and to time. We have dealt with the varying reaction of host and parasite, a notable example being given in the outbreak reported by Brouardel (Chapter III.), and it is a common observation that the disease assumes a very varying pathogenic quality in different outbreaks, and indeed, in different bodies of men exposed under precisely similar conditions at the same time (compare Influenza, Diphtheria, etc.). The fact has been noted that the disease does not always prevail in direct proportion to the extent of the susceptible *personnel* exposed in place or time, as is shown in the contrast between the large port garrisons and the continental cantonments (and in the incidence on the latter from year to year), and in the course of the rise and decline of the disease during the last quarter of a century. Some corps units acquire the disease so soon after arrival as to point to the probability of importation, others (a negligible minority) may escape entirely during the most dangerous first year of residence; we have also in some cases the phenomena of "infected regiments" so well marked as to compel attention, while in others there is only a sporadic case, or a few such at long intervals (chiefly in the non-endemic area); some link in the chain is absent. While always and everywhere the fresh drafts exhibit the highest incidence, this varies greatly even in the same area and station, as well as from year to year.

With this we have to note the definite limitation to certain companies and barracks on the one hand, and the capricious and baffling "destroying-angel" type that apparently selects victims indiscriminately from all corps and barracks without obvious connexion with a common source of infection; much of this caprice is merely apparent and due to defective data which would supply the connexion; to non-recognition of cases and to prolonged abstention from hospital on the part of the sick; and, further, to the special conditions of cantonment life and intercourse—the multiplicity of latrines, barracks, messes and water-sources— to the varying facilities for contact, mediate and immediate. These facts find a further illustration in the varying incidence on the different arms and classes—rank and file, officers, women and children—which however is seen to follow in a definite relation. But scarcely one of the facts is compatible with the theory of the ubiquity of the infection in the environment beyond cantonment limits; the operation of the disease-agencies is far more restricted than the conditions common to the *personnel* or locality.

Then as regards locality, we have the universal range of the disease with great diversity in place under similar conditions of *personnel* and climate; we have "infected places" whence the disease never dies out, and others, where, if introduced, it is confined to a sporadic case, or a sudden "heaped-up" outbreak with subsequent immunity for long periods. Where the disease is truly endemic we have most marked fluctuations in the incidence from year to year, and yet nothing is better established than a definite association with certain areas, zones and places in a comprehensive record. While the influence of climate cannot be excluded, as is certainly demonstrated in the definite local and seasonal incidence, we have to take account of the comparatively equal prevalence of the disease in the sub-tropic plains (endemic area) and in the associated hills (4,500 to 8,000 feet above the sea-level) which, however, provides the clue to this and many other of the problems of variability in place and time and on *personnel* (Chapter V.). We recognize that the results for any body of men depends largely on the locality occupied and on its previous history in regard to the disease, a distinct influence apart from importation and from any infection already existing in the corps, and this connotes a "place infection," or local conditions favouring development and propagation. And on the lowest estimate of the viability of the germ in external nature, we can see how the long-continued occupation of certain sites by a succession of highly susceptible individuals must, under the conditions of conservancy in vogue, provide a constant reinforcement of infection to the soil, the latrines and the barracks within cantonments. But after all, it is clear that the conditions necessary for the origin and spread of the disease are exceptional and variable, and that the facts of the local incidence are incompatible with the omnipresence of the virus in the environment beyond, which is everywhere equally open to the same reproach of gross sanitary neglect.

We need not dwell further on the apparent anomalies of the incidence in time and season. Some of the most marked of these are clearly due to the reversal of the climatic conditions in time owing to varying latitude (north or south), and within the limits of India itself we have a remarkable example in the case of Quetta (Chapter IV.). Climate and season clearly operate by influencing variously the three terms involved in the disease process, and the results will be modified by their variations; in the case of the host, by predisposing to, or fortifying against, the infective process; in the case of the virus, by affording conditions favourable or inimical to its viability and propagation, and to its spread by mediate contact (dust, insects, etc.), or by determining the pollution of common water-sources (rain).

The characteristic triple rise in the curve which is peculiar to the endemic area in India, while partly dependent on the duplicate course of the seasons so marked in the agricultural calendar, is largely determined by the presence and movements of the *personnel*, as shown especially in the winter rise, in the more or less continuous level of incidence sustained in the Hills, and in the influence, tending to marked seasonal aberrations, of more widespread outbreaks in campaigns. And once more we must conclude that a common factor like climate will not account, *per se*, for these results; that while the incidence is definitely and clearly associated with certain climatic and seasonal phenomena, these only operate mediately; and that in this connexion (when regard is paid also to the course and rise and decline of the disease) we cannot postulate justifiably the universal prevalence of the infection in the native surroundings, but must look rather to the conditions, of *personnel* and infection within cantonments.

Lastly, it may be noted in passing, as bearing on the original sources of infection, that the relative incidence on the various foreign and colonial garrisons occupied by British troops does not appear to bear any demonstrable relation to the ascertainable facts of the prevalence of the disease among the native inhabitants of the countries occupied. The rates returned from the Mediterranean ports are consistently much lower than those from Egypt which approximate closely to the Indian rates ; the general experience, which by its constancy assumes the force of a rule, is to demonstrate a marked rise in prevalence as we progress along the route to India, with a great decline to the lowest point in the Far East. The sustained contrast between the incidence on the Mediterranean and Egyptian garrisons, respectively, equally with that which marks the returns from India and the Far East, lends no support to the view that these variations merely depend on the varying prevalence of the disease among the native populations with which the troops are in contact. The evidence in favour of the liability to Enteric Fever of natives of the Far East is quite as cogent or defective as that on which the assumption is based in regard to the natives of India and which finds expression in the uncompromising statement that they are "saturated" with the disease. In the Mediterranean our troops are cantoned in close contact with all the conditions of old unreformed civilizations, in which Enteric Fever is known to prevail, but for Egypt we have unimpeachable evidence of a very definite measure of immunity from the disease enjoyed by the natives. Sandwith says that "whereas Enteric is very seldom absent from the European hospitals, it is a very rare visitor to the wards of Egyptian hospitals, which are frequented almost entirely by natives. This is true of some 25 hospitals." *Post-mortem* statistics fully bear out this statement. Sandwith never met with a case in the autopsies performed by him, and other observers have recorded only one doubtful case in a total of 1,935 *post-mortems* on natives. No single case of the disease was found among several hundred autopsies on children under five years of age who represented the poorest and most destitute stratum of the urban populations of Cairo and Alexandria. The records of the native army confirm these conclusions : Enteric is not altogether absent, but is relatively very rare, and Sandwith suggests that the native recruit "becomes liable to a slight amount of the disease while he is in contact with Europeans." Such evidence cannot possibly be ignored and its bearing on the Indian problem is obvious (see Chapter IX.). In fine, the result of the whole body of evidence adduced in the foregoing pages and the considerations which are enforced by a study of the anomalies of the epidemiology, point to the necessity of a revision of the facts and of our interpretation of them, and the essential point for a new departure is the adequate conception of the rôle of the human host as herein set forth.

We have now to deal with certain characteristic features of the epidemiological *facies* as revealed in the incidence of attacks on aggregations of corps units and on their constituent elements. In all enquiries of this kind, it is necessary to keep in mind, and to apply constantly, the following three considerations :—

1. The period of Incubation and the period of Infection ; the viability of the parasite within and without the body of the host ; with this,
2. The means and modes of Dissemination : and
3. The amount of Susceptible *Personnel* exposed, and the conditions under which it is exposed.

After what has been said previously on these points, a few words will suffice to indicate their bearing on the problem. The period of incubation has received attention from many observers with results that should warn us against the danger of the working assumption which fixes it at an average of two weeks. Engel went through all the available literature, but found only 88 cases that could be safely used as a guide, and of these a few showing periods of 1, 2, 33, 42, and 45 days respectively, were ultimately rejected as doubtful. But periods of from 4 to 32 days were regarded as fully established, the most frequent being 14 days, then 18, 21 and 8 days, in the order given. (Inaugural Dissertation, Strassburg, 1899—*Hyg. Rundschau*, Vol. X., page 596.) An analysis of the evidence afforded by the experience of the American Camps (1898) led the Commissioners to the conclusion that "the average period of incubation is probably about ten-and-a-half days". In an independent communication, summing up the results of their work, one of the Commissioners (Vaughan) expresses the conviction that the period may range between 8 days and 8 weeks (*Phil. Med. Journ.*, June 9th, 1900). But this point must always be considered with relation to the viability of the bacillus, within, upon and outside the body of the host ; the virus may be carried on the person or effects for some considerable time before it finds effective entrance into the alimentary tract ; the link of connexion is often lost in cases of mediate contact and in those of true direct contact where the previous case is never recognized, either because no pathogenic signs were evident or because these were misread. As regards the period of infection, we know this to extend to weeks, months and, in a small minority of cases, even to years ; that the periods of special danger are those preceding and succeeding the recognized attack, *viz.*, during the incubation and the early stages (which are prolonged in India owing to the disinclination of the men to "report sick"), and during convalescence and recovery. We have also to take account of the protean forms assumed by the malady, of light, ambulant cases and of the hospitality afforded to the germ by individuals in apparent health. With the numerous foci of infection in a cantonment in the endemic area and the special means of dissemination in operation, there is also the probability that the majority perform this office at some time or another, and, in many cases, repeatedly,—analogy of Tuberculosis and Diphtheria. Nothing definite can be stated on the question of the "latency" of the germ in the body pending the acquisition of pathogenic qualities under favouring conditions, but the probability of this must not be overlooked.*

This brings us to the means and modes of dissemination : the infection leaves the body of the host in the alvine and urinary excreta (occasionally in the pulmonary), and we need not pause to point the significance of this fact under the conditions prevailing in cantonments ; one infected subject may scatter the virus in one or more latrines and in and around the barrack in which he lives long before his illness is recognized, if, indeed, it be ever recognized. The disease is spread by the transfer of the infective excreta of one subject to the alimentary canals or, not infrequently, to the lungs of others ; the host is the prime source of infection and the chief means of dissemination, by his movements and his intercourse, frequently extending to other communities and over enormous distances. For the rest, it is only a question of the means of transfer, of the effective access from one host to another, and as regards this, we recognize in the first place, the efficacy of direct contact, and, next, of indirect contact in various gradations of remoteness. It may be through infected clothing or bedding passed on to others (South African blankets) or by contamination of other clothing at the "wash" ; by deposit of the virus in latrines and trenches, and on the site and its subsequent adhesion to the persons and clothing (boots, etc.) of others. But when the infective agent has escaped from the host the way is open for the operation of other agents

* In reference to the subject of viability within and without the body of the host, the parasitic and saprophytic life-stages of the virus, see the remarks on Comparative Epidemiology at the end of this chapter.

of dissemination, as by polluted dust to open water-sources and food, or direct to the person ; by flies or other insects in similar ways ; or by rainfall to open and high-level subterranean water-sources. The foci of infection are constantly reinforced and multiply, and several means of dissemination may be in operation simultaneously. The general results as shown in the character of an outbreak, will depend upon the local conditions,—on the character and extent of the *personnel* exposed, aggregation, facilities for personal intercourse, common centres of resort ; on the number and arrangement of barracks, latrines, cook-houses and wells ; on the nature of the soil and the climatic conditions. We have to note that, having regard to the peculiar circumstances of the life and domestic economy in cantonments which are in complete contrast with those under which the civil population exists, there are certain broad lines which ordinarily separate different modes of dissemination, and thus we have important contrasts in the epidemiological *facies* in the different communities. In the one case, the circumstances favour the occasional exposure of a community to one common and simultaneously acting agency of infection, while minimising the effects of direct contact ; in the other case the sources are usually more constantly present, multiple and discrete in time and place, depending on contact, more or less fortuitous ; no one factor is equally common to all at the same time, but the infection is passed on from one case to another with the intervals necessary to incubation and effective propagation. Of course, similar agencies may, and generally do, operate in both types ; a general water-borne epidemic is supplemented by contact cases, and a contact epidemic may consist of small group outbreaks (each from a common source) linked up by isolated cases at intervals. In a previous chapter a sketch has been given of the main features of the soldier's environment in cantonments which should bring before the reader's eye the essential contrasts that differentiate it from that of a civil community in the West and which should facilitate the apprehension of the opportunities and means for the mediate transport of infection, apart from the intervention of drinking-water, to which a distinct rôle is certainly not denied, and as to which the evidence has been analysed. With the abundant and constant facilities for the deposit of the bacillus upon the open soil in close proximity to the barracks and kitchens, the rôle of polluted dust must take a very different place among the factors operating in a sub-tropical cantonment than it assumes in a well-ordered town in England. And the same remark applies equally to the part played by flies, the life processes of which are definitely associated with fæcal filth ; we may, indeed, find some analogy in their agency in this connexion with that performed by insects in the fertilization of plants, in the maintenance of the cycle of life of intestinal parasites as the medium that connects the saprophytic and parasitic stages thereof.

As regards the character and extent of the *personnel* exposed, we shall not exhaust the reader's patience by a repetition of the considerations which have been the main theme of this essay, and which provide the clue to the main problems of the epidemiology. It is clear that the characters of an outbreak will depend, in the first place, on the amount of the susceptible material exposed to risk, and upon the relations subsisting between the individuals of the community ; and of the predisposing factors of age-constitution, first service, and of other morbid influences enough has been said. We may merely emphasize the influence of the *actual* numbers of susceptible subjects in any given community in regard to the disproportionate effects on the resulting rates; the fluctuating nature of the community, with constant reinforcement, and periodic accumulation, of susceptible individuals ; the exigencies which necessitate aggregation, centres of common resort and intercourse within each community and with other similar communities, in view of the facilities for rapid and extensive intercommunication now provided. The results of these influences in their aggravated form have been exhibited in the experience of camps and campaigns, while their varying operation on the different arms and classes of the service have been noted. Lastly, account must be taken of the influence of previous experience, both of the environment and of the disease, whether acquired in India or in other sub-tropical regions, as affecting the relative susceptibility of the *personnel ;* while the rapid and more frequent communications with these foreign and colonial outposts enhances the risks of importation.

If, now, these considerations be carefully focussed in the mind's eye,—the period of incubation and of infection, the means and modes of dissemination, the character, as regards susceptibility, of the *personnel*—it will be recognized that the epidemiology will be stamped with a very different *facies* from that exhibited by, say, Influenza on the one hand, and by Syphilis on the other, though all three are chiefly, if not entirely, spread by contact. There is no need to define the distinctions in detail, but the illustration will assist in the application and orientation of the facts of the case before us.

What, then, is the characteristic epidemiological type of the outbreaks with which we have to deal in India; what are the salient features of the incidence on the communities exposed as a whole? In Enteric Fever three types, more or less distinct, may be defined, *viz.*: first, the purely sporadic form, isolated cases at more or less considerable intervals, and having no apparent connexion, the disease being totally absent for long periods; second, sudden explosive outbreaks derived from a simultaneously acting agency which affects a whole community with common and fairly equal force and takes toll of the susceptible subjects in proportion to the extent of its operation in place and time; and, thirdly, a modification and combination of these types, in the form of small group outbreaks owning a common origin from a central focus, with isolated cases at intervals, which often appear to link up the group outbreaks, the intervals frequently corresponding to the ordinary range of the period of incubation. In view of the facts previously presented, there will be no difficulty in recognizing the first and third of these types as those familiar to Indian experience, in the non-endemic and the endemic area, respectively.

As regards the "sporadic" form, it must be noted that the term is often used loosely to cover two varieties of incidence:—the true sporadic, in which one or more isolated cases occur at long intervals, and apart from any obvious connexion with a previous case in the same place, and depending on casual importation; and the so-called "dropping" cases, at more or less considerable intervals, that may have their origin in importation, and then localization and indirect contact come into play, the results being determined by the local conditions and by the extent and relations of the susceptible *personnel* exposed. In all essential respects this latter form may be justly included in our third category. The sporadic forms (true and false) derive importance from the fact that they are taken by most observers to indicate without qualification infection derived from contact with the native environment, but some prime considerations are unremarked, if not overlooked, in this connexion. Among these are the probabilities of importation from another cantonment, the evolution of conditional parasites, the non-recognition of previous cases more or less typical, the hospitality to the virus afforded by apparently healthy individuals, the viability of the virus in the host and in the external nature, and the possibility that infection acquired in the native surroundings may be derived from the men themselves.

The contrast between the second and third forms set forth above is due to the means of infection operating in each case—in the former, simultaneous, in the latter, subsequent, and the respective curves of incidence differ entirely in their rise, culmination and decline. In the one case, there is a sudden steep rise culminating rapidly to a lofty fastigium (corresponding to a simultaneous widespread infection of comparatively short duration), with an almost equally abrupt decline to a low level, and finally, a gradual tapering off to extinction, representing, as a rule, the supplementary contact infections. The characteristics will, of course, be modified by the character and extent of the common agency and of the community exposed, *e.g.*, polluted food or wells, or larger general water systems. And it is to be noted that water may act not only as a vehicle, but also as a nidus for the propagation of the virus, and this will affect the epidemic *facies* to some extent. In the other case, we see a far more gradual and irregular step-like curve, with flatter and longer course, broken by depressions and rising suddenly at intervals to higher points, these features being common to both rise and decline in different degree; or we may have nothing that can be called a "curve," but a chain-like succession of one or more cases at intervals, like beads of different sizes on an attenuated string. The two last forms are obviously fundamentally based on similar phenomena and differ only in the number and rapidity of the sequence of events,—which is, again, merely a difference of degree, depending on the amount of susceptible material, on the number of foci of infection, and on the facilities for contact. As we see, certain features are common to all the three main types, but in such different degree that they may be easily differentiated as a rule; occasionally the factors operate to mix the types, or some one common feature may be exaggerated to cause one type to approximate to another (see, *e.g.*, the extensive contact epidemic at Beuthen, described by Noetel. in *Zeitschrift f. Hygiene*, Vol. XLVII., h. 2, p. 211, which exhibited some of the characteristic features of a water-borne outbreak). Now, having regard to the character of the *personnel* exposed and its disproportionate susceptibility, we could not but expect that the second of our incidental types (the "explosive") would find most favourable conditions for display if one common, simultaneous agency were ordinarily in operation; there is nothing whatever in the more limited strength of a corps, still less in an aggregation of corps, to militate against this conclusion, and an example has been given of a regimental outbreak due to specific pollution of the common water-supply which bears this out fully (see Chapter VI. and *Zeitschr. f. Hyg.*, Vol. XLVI., 1904, p. 23). The inference is therefore clear and unavoidable; the third epidemiological type being definitely and constantly characteristic of the incidence in the endemic area, we are forced to look to the influences of contact, direct or indirect, as the controlling factor in propagation and dissemination. And this conclusion receives complete confirmation from the experience of camps where the conditions are, on the whole, still more conducive to the common, simultaneous, explosive type, which, however, is the rare exception.

For the rest, we need only commend a study of the typical diagrams given in Chapter VI. as affording the best evidence of our contention. The reader may also be referred to the detailed discussion of the influence of the drinking water-supplies on the course of the disease and its local and seasonal incidence (Chapter III.) as to which we may merely recall the conclusion arrived at, that no definite inter-relation could be established to explain the characteristic phenomena of our cantonments, though water doubtless acts as a fortuitous vehicle, but in a way and on a scale which scarcely differentiates it from other local foci which play their part in the chain of indirect contact infections; some of the main considerations in this connexion are discussed on a subsequent page, when the meteorological phenomena are dealt with. When we compare the course and rise of Enteric prevalence with the simultaneous decline in other "water-borne" diseases, Cholera, Dysentery and Diarrhœa, we must infer the operation of different factors; one common factor cannot possibly control the incidence of the former and the latter diseases, in anything like equal measure. Moreover, the latter may be said to be as rife now as formerly among the native population, from which also the respective infections were largely derived; as in the case of Enteric Fever the younger men and the new arrivals exhibit a special liability to these disorders, and yet they have been reduced to a minimum, and practically abolished in epidemic form, in the European army. It seems obvious that this complete contrast in the course of events is inexplicable on the assumption of the operation of a common factor, and we are compelled to revise our broad conceptions of the etiology of the one or of the others. When the position is surveyed in detail, as in the account rendered in the foregoing chapters, we recognize the limitations of the results of the sanitary reforms which have marked the last thirty years of the record ; these results in the sum represent a very notable achievement and are patent in the reduction of the morbidity from practically every cause, save only in the case of Enteric Fever, and we must conclude that it is in respect of the predisposing and effective causes of this disease only that our efforts at amelioration have failed. And the clue to this failure is found in the etiological considerations set forth, which may be stated briefly as the continued aggregation with constant reinforcement of susceptible subjects and the facilities provided for the transfer of excretory products from subject to subject ; that is to say, our conservancy arrangements do not avail to cut the channels of communication between the intestinal tracts of different individuals ; and a study of the facts regarding the conservancy arrangements should dissipate the mystery of these deplorable results, and indicate, further, the true sources of the evil as present within the community itself. Our Enteric Fever is, on this view, the approximate measure of our sanitary default, and thus we pay the penalty, not only in the shape of scattered, isolated cases, with an occasional small outbreak which is soon brought under control, as in the case of Cholera in recent years, but we have it ever with us and practically everywhere, with only some difference in degree which we must refer to local conditions, more or less favourable. An instructive parallel is afforded by the case of Diphtheria in England and Wales during the quarter of a century following 1870, when the sanitary era was fairly inaugurated. During that period of reform, the combined death-rate from the seven principal "zymotics," including Diphtheria, fell from 4·8 to 2·5 *per mille*, and that from Enteric Fever from ·37 to ·17 ; but the mortality from Diphtheria rose from ·12 to ·19 (63 *per cent*), while in the larger urban centres the ratio of incidence was trebled. It has been impossible to connect this disease with polluted water-supplies, and it is accepted that in the vast majority of cases the infection is conveyed from case to case by contact, direct or indirect, mild or unrecognized attacks (" sore-throat ") maintaining the race (virus) and linking up the definite outbreaks. The increase has been associated with the extraordinary growth of the urban population and with the great extension of national compulsory education, involving the aggregation in schools of the most susceptible members of the community, *viz.*, children from 3 to 12 years of age. No one can fail to recognize the obvious analogies with Enteric Fever in the army in India which these facts disclose, but which extend, indeed, beyond the broad epidemiological phenomena. We see these analogies exhibited with striking force in outbreaks of Enteric Fever where the disease is endemic in rural areas as in Western Germany (see Koch: "*Die Bekämpfung des Typhus*") and in England. In this connexion a recent report of Dr. Sweeting to the Local Government Board on an outbreak in certain closely connected villages in the shires of Buckingham and Bedford is instructive. At the end of July, 1904, five cases of Enteric were notified. Subsequently 21 other cases were certified, and Dr. Sweeting found seven others which had been looked upon as "influenza." The sum total of undoubted cases appeared to be 33, of whom 27 were school children. There was no community of the milk supply or other food. Attention was therefore directed to school influence, and particularly to the question of water-supply. The latter was obtained from a shallow well which showed signs of pollution from the surrounding surface, upon which, within two feet of the well, was found a considerable heap of decomposing excrement mixed with a few ashes, which had been accumulating there for some weeks prior to the outbreak. This excrement was derived from four pail closets, the contents of which were thus deposited for farmers' use. Although Dr. Sweeting was unable to ascertain the source of the specific contagion, he considers the pollution of the well water to be the probable cause of the outbreak. Previous to the outbreak there had been a number of cases of ill-defined illness which may have been ambulant typhoid. There is, further, the fact of the endemicity of Enteric in the district.

Examples could easily be multiplied, but we must return to the indications which these epidemiological considerations afford, while bearing in mind that in Indian cantonments we have, in general terms, a combination of the primitive conditions characteristic of rural areas together with the quite peculiar factor of aggregation of susceptible subjects. It is claimed that the evidence can only be satisfactorily explained on the view that regards the infection as present within cantonment limits, in the bodies of the men or in their immediate environment, and that it is spread by contact, mediate or immediate. And this standpoint does not at all involve the necessity of distinguishing between the sources of infection in "sporadic" cases and in group outbreaks; a closer view points rather to their identity and to the interdependence of the two forms. Fæcal contamination of soil, air and water is so universal in India and the East, and the distribution of the disease in place and time is, at the same time, so comparatively restricted and so definitely conditioned that we cannot postulate the ubiquity of the infection outside cantonments, and we must infer the necessity of the operation of the specific "cause" within the range of its effects. The universal prevalence of excremental filth is not confined to the native environment, but is an inalienable result of a faulty sanitary system under which the soldier lives and to which he directly contributes ; it may, and must, predispose to the disease apart from the presence of the specific virus, and it provides the facilities for its propagation and spread. And the same conditions apply equally to the uninfected and to the infected excreta. The rise and course of Enteric Fever in time and its local incidence bear no definite relation to that of other diseases recognized as acquired by contact with the natives and their environment, which must be taken to have remained unchanged during the last thirty years, save in respect of the influences brought to bear by the presence of Europeans.

It is submitted that the natural history of the infective agent, its parasitic faculties, its viability and its modes of dissemination, have not been adequately appreciated ; that, consequently, there has been failure to recognize and appraise the facts of importation on the one hand, and of local endemicity on the other hand. In regard to both we have seen the results following in direct ratio to the sum of the etiological conditions set forth (camps, campaigns) and, further, a direct relation between the results in places at a remote distance from one another, *e.g.*, Egypt and India ; South Africa and India ; trans-frontier campaigns and India ; Plains and Hills.

The infection in some form is always present locally in the endemic area ; thus there are always foci from which wider outbreaks may develop and for dissemination by traffic, though the links in the chain of infection are generally lost to observation : healthy *bacillenträger*, unrecognized, light and ambulant cases, convalescents, etc., as also local foci in the environment. (Analogies are found in the cases of cholera and diphtheria and of plague as an epizootic.) One centre may be exporting and importing infection at the same time to the confusion of observers, but in the phenomena of barrack and company infections (reinforced by the experience of school influence in diphtheria) we have a valuable clue to the epidemiology which demands intelligent prosecution.

In years of comparatively high prevalence, most centres return high rates—the influences in operation are general over a wide area—but there are marked variations from year to year in the incidence on any one locality, and this is largely due to variations in the *personnel*, and in the external conditions, meteorological and telluric, affecting host and parasite and the means of access of the one to the other.

Let us now summarize the evidence in regard to these physical conditions. We recognize a distinct relation between the prevalence of the disease and the drier, continental areas, and, further, to drought and to first rainfall after drought. Waldo has pointed out that "the intensity of oscillations of rainfall (marked alternations of dry and wet weather) increases with the continentality of a region;" and this is especially the case in the tropics. It is scarcely necessary to give a warning against the assumption that because the disease is most prevalent at two most contrasted seasons (hot dry weather and monsoon) there is any essential and irreconcilable disorder in the forces in operation. The explanation of the paradox lies in the difference in the results raising from rainfall during continuous rain, and from intermittent precipitation at longer intervals, and, *a fortiori*, from the first tropic downpour after prolonged drought. Beyond the effects on the soil and, through it, on micro-organic and insect life processes, the rainfall operates largely as a vehicle placed at the disposal of a dry soil for the transport of any infective agents present therein to the water-supplies; proof of this has been adduced in the results of bacterioscopic examinations of open and subterranean water-sources. But we may also recognize a relation between the total amount of rainfall and Enteric prevalence, for the disease has been shown to occur in its endemic form in precisely the area of lowest average and most capricious precipitation, as signified by the provision therein of enormous irrigation works or of projects for their extension. Indeed we may say, generally, that the main endemic area corresponds approximately to the region lying between the full influence of the two great monsoon currents and subject to frequent failure, or aberration in the course, of one or other or both; together with the table-land (Deccan) which is sheltered from the western current by the barrier of the Ghâts (see Chapter III.). This relation to the relatively dry continental area and to first rainfall after drought derives special significance from the fact that almost precisely similar phenomena have been shown to be associated with the endemic incidence of diphtheria (Newsholme). We could not expect to be able to demonstrate the relationship in India as a whole in different years when drought or excessive rainfall, respectively, was experienced, for the reason that the conditions are never common to the whole country. It is true that the endemic area, generally, was exposed during the last decade of the nineteenth century to a period of excessive precipitation (April 1892 to March 1895) followed by one of general defect in the next quinquennium (1895 to 1901) and that the Enteric rates recorded were consistently much higher during the latter period in which, as we know, they rose to their highest point, thus :—

TABLE LI.

India.

Period of excess Rainfall.			Period of Defect.			
Year.	Enteric rates per mille.	Rainfall: variation from normal ins.	Year.	Enteric rates per mille.	Rainfall: variation from normal ins.	
1891	20·4	−3·54	1895	26·3	−2·19	
1892	22·1	+5·09	1896	25·5	−4·83	
1893	20·0	+9·07	1897	32·4	−0·15	Frontier Campaign.
1894	20·9	+6·47	1898	36·9	+0·43	
			1899	20·6	−11·14	
			1900	16·0	−0·57	Influence of Boer War.
			1901	12·8	−4·13	
			1902	16·7	−0·37	

These data speak for themselves and do not establish a presumption of a definite and proportional inverse relationship whether we regard the factors as operating immediately or with deferred effect; the two years of highest Enteric prevalence (1897-1898) were associated with practically normal rainfall, and the years of most defective precipitation (1896-1899-1901) with, comparatively, the lowest rates. Still, when an analysis is made of the local areas affected, we do find evidence of the inverse relationship; for example, the interior districts of the Bombay Presidency were those chiefly affected by the defect in the latter period, and this may serve to explain in part the disproportionate increase in Enteric Fever that marks the history of the Bombay Command during recent years (see Chapter II.). This example has the more force in that the Bombay Command was subject in far less degree to the disturbing effects of other factors. For we have to recognize the operation on the course and rise and decline of the disease during the decade in question, of factors chiefly affecting the *personnel* and the conditions under which it was exposed, *viz.*, campaigns in 1897-98, followed by the suspension of reliefs and drafts during the Boer War, and the subsequent effects of "previous experience" in South Africa, when reliefs were resumed. (Chapter II.)

The annual rainfall in individual stations has of course varied to a much greater proportional extent during the decade in question, but here, again, it is difficult to trace any consistent direct or indirect relationship with the incidence of the disease in the same or the following year, when the *annual* admission rates are compared with the annual precipitation.*

The special characteristics of the agricultural calendar in India involving practically a definite duplication of the seasons of growth and of harvest, together with the double rise in the curve of Enteric Fever render it necessary, however, to analyze the data for the different seasons rather than for the year as a whole. When this is done for our endemic area we may discover certain well-defined relations between the rainfall and the actual and proportional prevalence of the disease in the different seasons. It may be laid down, as a very general rule, that in the first quarter of the year following excessive rainfall in the previous monsoon (July to September), there is a decided diminution in the proportional incidence of the disease, whereas after failure of the monsoon, the incidence on the first quarter of the following year is proportionally higher; the experience of the decade 1892-1901 shows that in the former case the first quarter yielded only 11 *per cent* of the total annual morbidity,

* In this connexion, see a valuable paper by Major Cockerill in *Journal R. A. M. C.*, for June 1905, on Enteric Fever, in Bermuda. He gives a chart showing the annual incidence of rainfall and Enteric Fever for 20 years, which exhibits clearly a well-defined inverse relationship in almost every year save 1902; but this was a year of an epidemic outbreak probably due to the importation of infection by Boer prisoners. This is the more striking as the Author does not draw the inference of an inverse relationship between the amount of rainfall and the prevalence of the disease

while, in the latter case, 19 to 20 *per cent* occurred within the period in question.

The results as regards the second quarter are very similar but less well-defined; it would appear that a defect in the precipitation of the antecedent monsoon determines, or is followed by, an increase both actual and proportional in the prevalence of the disease. In the third quarter, the relative prevalence is apparently determined by the extent of the rainfall of the *same* year, and this, of course, is the monsoon period: when precipitation is excessive, the amount and proportion of Enteric Fever rises, and the converse relation is equally well-marked. Lastly, the order of events in the fourth quarter is, again, very similar to that described for the first, and there we find an inverse relationship between Enteric incidence and the preceding monsoon rainfall. It is interesting to note at this point that we do not get these results in the case of Simple Continued Fever. The admissions therefor show a decided tendency to a disproportionate rise in the fourth quarter and in the first quarter of the following year after excessive rainfall in the monsoon period, and, conversely, defective precipitation is succeeded by a relative diminution of the disease returned under this head. A similar sequence of events is exhibited in the case of Remittent Fever, but it is not nearly so marked; we cannot overlook the suggestive indication of the relation to Malarial Fevers and the contrast with Enteric Fever, in both cases. These facts are of decided importance in their bearing on the phenomenal association with the disease prevalence, of drought on the one hand, and of first tropical rainfall after drought on the other hand, which marks the epidemiology in India, and in other places under totally different conditions. Their value is enhanced precisely because on a *prima facie* view there is apparent confusion and contradiction in the double association in the Indian experience; but with the key to the mode of operation of the factors in our hands, this confusion affords the strongest confirmation of the explanation set forth. We are thus able, further, to reconcile not only the discordant phenomena of the double rise in the disease curve in this country, but also those which mark the seasonal incidence elsewhere when it is compared with that of India, notably of Europe and America, on the one hand, and of Egypt and South Africa on the other.

We have briefly discussed the main facts of the position in the Transvaal (Chapter IV.), but we may supplement them by a reference to the account given of Natal in an able contribution to the A. M. D. Report, 1898, by Major (now Lt.-Col.) Simpson, R.A.M.C., which will well repay study. His diagrams clearly show that while the general correspondence between the prevalence of Enteric and the rainfall is very close, the disease curve rises much more rapidly to a maximum of shorter duration than that of the rainfall, and beginning to fall sooner, declines more rapidly. The commencement of the well-defined Enteric season coincides with the *first* period of most rapid increase in the rainfall, and the admission-rate ceases to increase, or begins to diminish, at a second period of most rapid increase in precipitation. The evidence in detail further goes to show that a prolonged dry season (whether normal or abnormal) when followed by heavy rainfall is associated with rapid increase in the morbidity.

The broad conclusion to be drawn from the facts and experience of the different and most definitely contrasted and widely separated areas, is that summer heat and drought provide the optimum conditions for the endemic and epidemic prevalence of the disease, and that rainfall operates on and through these conditions as a most efficient vehicle for the transport of the virus to the water-supplies, especially where these are obtained from a high and fluctuating ground-water and from open sources, when both are subject to the immediate influence of tropical precipitation. In the case of open surface sources (as in the case of Natal cited), the disease shows a rapid rise forthwith (allowing for the period of incubation), whereas in the case of the pollution of the ground-water through the soil, we have to note a temporary deferment of the results corresponding to the time required for the reinforcement of the ground-water.

It will be interesting to supplement the foregoing considerations by evidence derived under totally different conditions. We have already referred to the seasonal incidence of the disease in Egypt (Chapter IV.), a practically rainless area, the most notable feature being its suggestive association with the period immediately following the annual rise of the Nile; and this has been interpreted as indicating the influence of the ground-water which is reinforced by the river flood, and progresses in a horizontal and vertical tide through a fæcally polluted soil to the wells. Now it has been shown by Sir John Eliot (formerly Meteorological Reporter to the Government of India) in his Presidential Address before the British Association, that the rainfall on which the Nile depends for its annual flood, is subject to the same influences as those which govern the Indian monsoon current,—both are derived from the same source. Consequently, a heavy or excessive monsoon in India is associated with an exceptionally high flood in the Nile, and the converse is equally well established. Thus, in the three years of excessive monsoon, 1892, 1893, 1894, the Nile floods were abnormally high, while in 1896, 1899 and 1901, when the monsoon was in serious defect, the levels attained by the river at the flood periods were the lowest on record. Let us now set forth the annual incidence of Enteric Fever on the European garrisons at Alexandria and Cairo for the series of years embracing these phenomena, omitting 1898 in which the Soudan (Khartoum) Expedition occurred with the usual results in greatly increasing the prevalence of the disease, and in vitiating local records by its importation.

TABLE LII.

Enteric Fever in Cairo and Alexandria, 1891-1902, *among the British Troops in Garrison. Ratios per* 1,000.

	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1899.	1900.	1901.	1902.
Admissions ...	12·6	35·1	20·5	21·2	16·2	13·2	6·7	7·25	18·6	{ 10·0 16·9	17·4
Deaths ...	2·84	10·31 *	5·32 *	4·02 *	2·78	2·64 †	1·80	1·61 †	2·53	4·62 †	3·54

NOTE—* Denotes years of high floods of Nile.

† Denotes years of lowest floods on record.

Two admission rates are given for the year 1901, *viz.*, 10·0 and 16·9 *per mille ;* the former represents the incidence of the disease *in* Cairo and Alexandria, with which we are concerned, the latter includes 27 cases that occurred during one week among troops in camp for manœuvres (A. M. D. Report, 1901). Considering the fact that direct contact infections cannot be excluded, the significance of these figures will be admitted ; the years of high flood are invariably associated with the highest prevalence of the disease ; whereas Enteric falls away to its lowest points with the failure of the river to rise to its accustomed level, the only partial exception being in the results for 1897, which may probably be connected with the low Nile of the preceding year. The phenomena have an important bearing on the influence of rainfall on the ground-water in monsoon areas, the Nile flood operating probably in the same manner as heavy tropical precipitation on a foul porous soil after drought.

The case of Bangkok (Siam) affords corroborative evidence. Dr. Campbell Highet reports that the disease shows two distinct periods of prevalence: one following shortly upon the advent of the annual wet monsoon and continuing until near its close, the other in the "winter," the second notable rise being experienced in December. Now the water-supplies are drawn mainly from the open canals which are also the common sewers; the rainfall doubtless acts by washing excremental filth into the canals (and from the roofs of dwellings where it is caught and diverted into storage tanks), and the second (December) increase may be confidently associated with the very high tides that prevail during November. These tides cause a rise in the level of the subsoil water to that of the ground surface; "the canals overflow their banks, wells are flooded and a general soakage of the soil with the sewage of the canals is the consequence" to be followed by cases of Enteric Fever after a period of two or three weeks. (*Journ. Trop. Med.*, October 1st, 1904.)

Such then are the facts, and in endeavouring to grasp their significance, it was never more necessary to secure a stand-point from which the wood will not be obscured by the trees; individual facts must not be allowed to distract our vision from a conspectus of the evidence as a whole. The reader must be referred to the discussion of the considerations involved in the meteorological and telluric phenomena and of their *modus operandi*, given in Chapters III. and IV., but here we may bring those considerations to a focus in the briefest terms.

So far as the external environment is concerned in the maintenance and spread of the infection, we see the soil as the receptacle of fæcal matters in which the virus leaves the host to find conditions more or less favourable to ectanthropic viability as determined by the circumstances of place and time (season): nature of soil, moisture, pabulum, heat, direct sunlight, etc. We need only recall the fact that Sidney Martin found a great contrast in the relative viability of the bacillus in different soils; those of a clayey, loamy and garden mould composition being favourable, while sand and peaty soils were as decidedly adverse. We have noted the facts demonstrated by Klein as to the favourable influence of nitric and nitrous salts, which moreover Emmerich has confirmed in studies on the saprophytic viability of the cholera vibrio. These vibrios thrive in soil rich in nitrates, which they reduce to nitrites and this faculty is directly associated with an enhancement of their virulence as pathogenic agents. (*Munch. Med. Wochenschr.*, 1904, No. 25.) The period of drought after the fall of leaves and vegetation in the "spring" is favourable to nitrification and micro-organic life under the influence of aeration of the soil and a rising current of moisture in capillary currents. (See Chapter IV.) From this constantly reinforced reservoir of infection we have to follow the course of the infective agent to the entrance of the alimentary tracts of fresh hosts, and it is easy to see that this course will take different directions under the varying conditions of drought and rainfall, according to the vehicular facilities provided. To put it very crudely for the sake of emphasis, we may say that, in the one case, the course is upward through the air, and in the other case, downward through, or on, the soil to the water-supplies, but in both cases vicissitudes involving risks of non-access are encountered by the germ, whose progress to its goal is often made by stages and ricochets, rather than as an arrow to the mark. In the former case we have to recognize direct contact of infected soil with the clothing (boots) and person; next, the vehicular rôle of flies and insects, carrying infection to food or water-supplies, or direct to the host. But, doubtless, no agent is so powerfully operative as dust before it is sterilized by radiant heat and light at the acme of the hot season. Its course may be, as in the case of flies, indirect, but there is good evidence for the assumption of a more direct passage to the host, who is generally a mouth-breather, when the atmosphere is always fully charged with dust; and everyday experience shows that large quantities are ingested. The mouth and fauces, nose and pharynx are, literally, a trap for dust, and apart from unconscious deglutition, the frequent libations necessitated by the thirst engendered by heat, carry large quantities of dust into the lower intestinal tract. This would appear to be obvious; but we are still in the category of broad inference—of cogent force, nevertheless. But we shall go far to provide the contention with more decisive sanction if we look to the seasonal incidence of the common infective throat diseases, *viz.*, "sore-throat," tonsillitis and quinsy. The connexion is important from a two-fold aspect, *viz.*, the recognized dependance of these affections on infective air-borne dust, and from the constantly recurring observation of attacks of Enteric associated with initial symptoms of sore-throat. It is not impossible, further, that in view of their structural and functional similarity in certain points to Peyer's patches, the tonsils and pharyngeal glands may afford a *locus resistentiæ minoris* to the attack of the bacillus. Let us now see how the incidence of ordinary throat diseases falls upon the different months of the calendar year :—

TABLE LIII.

Seasonal incidence of Sore-throat, Tonsillitis and Quinsy by Commands and on India as a whole. Actual numbers of admissions in 1904.

Command.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northern ...	27	40	26	37	51	47	37	35	42	34	39	45
Eastern ...	23	15	34	54	42	37	39	36	42	34	24	22
Western ...	30	36	66	40	43	41	31	24	17	29	32	49
Total of above	80	91	126	131	136	125	107	95	101	97	95	116
ALL INDIA ...	107	121	143	145	172	146	133	123	116	124	124	139

This will be allowed to be very suggestive when compared with the rainfall data and the seasonal incidence of Enteric; the facts for one year only are available and we must be content with the main broad indication, *viz.*, that infective dust diseases are notably and definitely most prevalent at the time of one great rise of the Enteric curve ; an analysis of the returns for a longer period would doubtless provide the key to certain other features of the seasonal curve of Enteric Fever, and, as it is, we note that the rise in the incidence of throat diseases is earlier in onset in the Eastern Command (Bengal), than in the Northern Command (Punjab), in correspondence alike with the order of the meteorological phenomena and with the Enteric incidence in these areas, respectively. Now apart from the actual presence of the infective agent, this dust must contain fæcal matter and the associated micro-organisms in abundance, and we may see in this fact one cause of the rise in bowel complaints (dysentery and diarrhœa) at this period ; and in any case there must be some derangement of the normal balance of the intestinal flora, and access of the agents of a mixed infection. (See Chap. III.) Again, if the facts which have been presented in regard to the contrast in the nature and composition of the soils, in the different parts of the endemic area, be taken into account, (compare Upper India with Deccan, Chapter IV.) we are now in a position to understand the contrast in the relative prevalence of the disease in the hot weather and in the monsoon period which marks these areas. It is, further, notable that it is precisely in the true continental area of Upper India that the atmospheric content of dust is at its maximum, and that so-called dust-storms are characteristic phenomena of the hot weather (March, April, May). In connexion with the viability of the bacillus in air-borne dust under these circumstances, we may recall the familiar fact that these "dry" dust-storms always lower the temperature of the air, and this must be due to moisture formed in the cloud overhead. Such moisture does not appear as rain precipitated, because it is re-evaporated before it reaches the earth, but it must favour the viability of the micro-organic life in the dust, and this just when desiccating influences would seem to be most powerful. The fact that Lung complications have been detected in fully 30 *per cent* of the cases of Enteric affords strong confirmation of the rôle here assigned to dust as a vehicle of infection.

Conversely, we know that the first effects of rain are to clear the air of dust and to lay it on, and prevent it rising from, the surface, *i.e.*, to abolish it, and we have seen that the first month of the monsoon period coincides with a fall in the curve of Enteric to a minimum. But *first* rain after drought, where the soil is fæcally polluted, will probably favour the micro-organic life in the soil; inasmuch, however, as dust is abolished we see no immediate increase in the disease. This is in abeyance for a month (apart from the time required for incubation), and we get no result until the water-supplies are affected, or rather, until the incubation period has been superadded to this event; water-borne filth diseases, in which the incubation period is shorter, precede Enteric in their time of onset (cholera, dysentery and diarrhœa). It must be remembered that the ground-water, generally at a comparatively high level, is the almost universal source of supply and that it fluctuates from opposite extremes under the influence of tropical rainfall and drought. Continued and excessive rainfall will therefore wash impurities into the water-sources, or raise the ground-water to the level of pollution with the same results ; but subsequently, the general effects will be a certain purification of the soil both from grosser organic matters and from infective organisms. Moreover, other essentials for the life processes of the latter will be removed, *e.g.*, nitrates, and while these, by gaining access to the water-supplies, may favour the viability of the germ therein for the time, they will, *ipso facto*, be greatly diminished in the upper layers of the soil ; and this will be true for other "pabulum," including air which is replaced by water. The temperature of the soil is also lowered to a point below the optimum for the saprophytic propagation of the germ. It is probable that we may find in these conditions important factors in the fall of the Enteric curve to the next minimum at the end of the monsoon, *i.e.*, in the interval before the "cold" season sets in, when the meteorological conditions approximate in some respects to those of the spring. It is at least a notable fact that the autumn rainfall in England determines largely the yield of the wheat harvest of the following year, inasmuch as a single inch of rain at the former period has been shown to diminish the ensuing crop to the extent of over one bushel per acre ; this association of excessive rain with subsequent defective plant germination is suggestive in the light of the facts of the quarterly incidence of the disease under the influence of variations in the rainfall during the preceding monsoon period. We can, at least, point to the fact that in the endemic area, an excess of rain in the monsoon period (July to September) is followed by a comparatively low actual and proportional incidence of Enteric in the subsequent two quarters ; while, conversely, a deficit in the monsoon precipitation appears to ensure a very definite increase in the disease in the following cold weather period.

Finally, while the facts require that we should look to the pollution of the ground-water as influencing the prevalence of the disease in the mid-monsoon period, we are forced to the conclusion that drinking-water after all plays but a secondary and fortuitous rôle, as an occasional vehicle in the chain of indirect contact. For although the records of the dates of attack sometimes show a greater tendency to small group outbreaks at this time, there is no constant and marked contrast in this respect, at all times and in all places, with the epidemiological type of the hot dry weather. But there are the special circumstances to be taken into account, *viz.*, the number and nature of the water-sources, which militate against the operation of a common, simultaneous source of infection. The number of wells in use varies greatly in different places but is nearly always large, and the measures employed to purify the water (boiling and addition of permanganate) cannot fail to effect beneficial results, though they are often far from irreproachable in respect to method and completeness. But a failure in the safeguards on one occasion with, possibly, evil results, is limited in its operation by the fact of the intermittent system of small supplies, each of which is separately subjected to the processes of purification. Having regard also to the prevalence of other bowel diseases at the time, which cannot be dissociated from the agency of drinking water, we may not overlook their predisposing influence, if only on account of their frequent antecedence to, and concurrence with, Enteric Fever. For the rest, we must look to occasional fortuitous specific pollution as providing the source of infection and beyond this, to all the manifold opportunities for its spread by contact.

In regard to other means of dissemination we have previously drawn attention to the possible rôle of lower animals (rats, dogs and other scavengers of human ordure) and of insects, ants, "dung-beetles" and especially flies. That human excrement provides a favourable nidus for the breeding of many species is well-known, and among these are the common and the so-called "small" house-flies. A reference to the Appendix to Chapter IV. will show how the seasons of greatest prevalence of these pests coincide in most stations with those of the maximum incidence of Enteric Fever. Major Aldridge, R.A.M.C., Sanitary Officer, Eastern Command, has made some exceedingly interesting and useful observations on the subject, which deserve attention and extension. From these it would appear that warmth and a moderate degree of moisture are the chief factors influencing vitality and propagation: the cold of winter, the drought of summer and the saturation of the soil in the monsoon period, seem to be prejudicial to the survival of the larvæ: it need scarcely be pointed out that if these observations be confirmed a key will be provided to some of the most striking features of the seasonal incidence of the disease, *e.g.*, the remarkable decline at the height of the hot weather.

"Full-grown flies are not, in most cases, to be found in large numbers at the trenches, no doubt because they do not find their natural food there; but the numbers of *larvæ, pupæ* and young flies, some of them with their wings not yet expanded, to be seen on turning up the earth, are so great as to make it difficult to avoid the conclusion that *the majority of flies in cantonments are bred there.* For instance, in a sixth of a cubic foot of soil taken from a trench 4,042 flies were hatched. It was further found that when the soil containing the *larvæ* was covered with six inches of dry earth free from larvæ the flies had no difficulty in emerging through this. On the other hand, when the soil containing the *larvæ* was kept saturated with water no flies appeared. From observation it would appear that the eggs are laid in the filth in the latrines, and the *larvæ* hatched out after it is put in the ground. If, therefore, the eggs can be killed in the filth the propagation of flies in this way will be put a stop to. In spite of its wide-spread distribution under varying climatic conditions the house-fly is not easy to rear under artificial conditions; but, experimenting partly with the eggs of these and partly with those of the blow-fly (*Calliphora*), Major Aldridge has found that they are somewhat resistant to most chemical substances; immersion for two hours in common salt, 10 per cent., mercuric chloride, 1-1,000, and crude carbolic acid, 2 per cent., failed to prevent the *larvæ* hatching out. On the other hand, immersion in any fluid for 24 hours seems to kill a considerable proportion of the eggs and all *larvæ*. It seems probable that a still larger proportion of the eggs would be destroyed by the putrefactive processes going on in sewage, while any *larvæ* hatched out would be destroyed in 24 hours. To test this, the following experiment was carried out at Jhansi in March 1904, when flies were breeding in great numbers in the trenches. A certain number of filth receptacles were left, full of sewage and closed, at the trenches for 24 hours, and the sewage was then trenched in the usual way. The Officer Commanding Station Hospital, under whose supervision the experiment was carried out, found no *larvæ* in the ground where this was trenched. Experiments will shortly be begun to see if treatment of the sewage in a septic tank, followed by aërobic treatment and irrigation on land, will prevent the propagation of flies. Even if successful, it is not to be supposed that by these means alone the propagation of the flies will be entirely prevented. Stable litter probably forms a favourite breeding ground for the house-fly and collections of garbage and refuse probably do so to a less extent, and these will require to be dealt with in a more systematic way than at present." (A. M. D. Report, 1904.)

The importance of the conclusion that the majority of flies found in cantonments are bred there, and of the indication to the disposal of the excreta by "biological" methods needs no further emphasis at this point (see Chapter X.).

A very few words are required on the subject of the variations in clinical type presented by the disease in India.* We may emphasize the conclusion that the pathogenic process is essentially identical in all parts of the world, and that we may meet with every gradation between the mild "abortive" form, frequently returned under the head of Simple Continued Fever, and the classical type in its most fatal form. As to the extent of the diagnostic error (not to speak of cases of infection

* By "type" we imply an "ordinary" case or "morbid mean"; there can be no real standard or archetype to which a disease *ought* to conform; a notion which tends to blind us to the variety and gradation of natural processes and the modes of "causation." (Allbutt.)

that never come under observation), we are not at present in a position to pronounce definitely; this, indeed, is one of the pressing demands of the problem. But attention may be again called to the fact that in very many fatal cases of the anomalous fevers Enteric lesions are found *post-mortem*, but comparatively so few cases of Simple Continued and Remittent Fever prove mortal, that, with the methods at present in vogue, we cannot hope to arrive at their true pathology. Further, it should be noted that, in the great majority of cases that end in recovery, the clinical symptoms are indistinguishable to ordinary observers from those which characterize the few that are found after death to fall into the true Enteric category. The question has been fully discussed in Chapters II., III. and VI., and we need only refer to the probability of the occurrence of paratyphoid and allied forms in far larger measure than is at present apprehended, and to the fact that these are not yet officially recognized in the returns.

As regards complications during the course of the disease, the records of 1,384 cases occurring in 1904 have been examined with the following results:—

—	Cases.	Per cent of total.
Bronchitis	276	20
Pneumonia	138	10
Pleurisy	6	·46
Hæmorrhage (intestinal)	138	10
Perforation	66	5·0
Phlebitis and Thrombosis	62	4·7

Epistaxis was very frequently noted; there were four cases of liver abscess (sequels); one of cystitis and one of colitis; diarrhœa is only mentioned, as a complication, in 8 cases. Curschmann (Nothnagel's *Cyclopedia*) gives the experience in Europe for some of the more prominent complications and symptoms as follows: hypostatic Pneumonia, 6 to 7 *per cent;* intestinal hæmorrhage 4 to 6 *per cent;* perforation, "under the most unfavourable circumstances in not more than 3 *per cent* of all cases," but it is said to be the cause of death in from 9 to 12 *per cent* of fatal cases. The contrast exhibited between European and Indian experience is very notable especially in regard to the Lung complications, which in India were noted in one-third of the cases. This is most suggestive in view of the facts already adduced as to the rôle of dust and the seasonal incidence of throat diseases. The sputum of pulmonary (Enteric) infection is very virulent and maintains its infective properties for several weeks.

The case mortality, and the various considerations to which it gives rise, have been fully discussed. The facts presented in regard to complications will serve to throw some light on one main feature, *viz.*, the comparatively high point which is still maintained though, as has been shown, there has been a steady decrease in the proportion of fatal cases along with the recognition of the disease. The predominant factors influencing the high mortality rate are (apart from failure to recognize the disease in all its forms) the lowered powers of resistance involved in exposure to a tropical climate (for this may be deemed truly tropical at the seasons of greatest Enteric prevalence) and the neglect of the men to report sickness in its first stages. This is well emphasized by the fact that the average duration of all fatal cases (including those in which the issue was deferred for months) may be put at 16 days, while in 40 *per cent* of the fatal cases it was (in 1903 and 1904) only 6·8 days. It is obvious that in seeking for fairly comparative data we must pay regard to age and to the conditions of army service in an alien and exhausting environment; such data may be said to be non-existent, or so rare and fragmentary as to be open to fallacy. But if we look to the experience of the French (European) army in Algiers-Tunis, we find that it has enjoyed but little advantage over our army in India in respect to either the extent or the fatality of the disease, as the following statement will show:—

TABLE LIV.

Enteric Fever in the French Army in Algiers-Tunis.

Corps.	1898.		1899.		1900.		1901.		1902.	
	Ad.	D.	Ad.	D.	Ad.	D.	Ad.	D.	Ad.	D.
1. Tirailleurs Algeriens ...	4·40	0·82	8·70	1·02	6·49	1·33	3·67	0·68	2·05	0·54
2. Spahis	10·26	1·47	15·37	2·61	6·73	1·96	7·46	...	5·79	1·38
3. Zouaves	26·51	4·18	45·03	4·95	33·12	6·33	37·34	6·27	15·72	2·16
4. Chasseurs d'Afrique ...	32·06	2·72	54·84	6·70	40·61	6·16	26·43	2·74	21·05	3·27
5. Infanterie legere ...	32·27	4·54	20·18	4·43	49·26	10·36	20·49	3·49	33·07	6·05
ARMY AS A WHOLE ...	23·47	3·57	32·07	4·43	23·92	4·95	21·55	3·56	17·80	2·88

NOTE.—Nos. 1 and 2 are native troops; No. 3, Frenchmen resident in Algeria; Nos. 4 and 5, Frenchmen recruited in France.

The case mortality on the 31,118 cases recognised as true Enteric Fever during the recent South African campaign (October 1899 to September 1901) was just over 19 *per cent*, but it is freely admitted that a very large number of attacks is not accounted for in this calculation and the fatality rate is therefore to be discounted. It must be said, when all allowances are made for the special conditions of Indian service, that the results which show a loss of one man in every four attacked by the disease in time of peace, are surely susceptible of improvement: moreover, by attacking the main causes of these results, we shall be exercising the most potent means of prevention.

A remarkable contrast in the clinical type and in the fatality of the disease process is frequently observed not only in the same stations in different years, but in different corps units in the same station at one time. Etiological considerations will provide the key to these phenomena. We have to take account of the varying susceptibility of the personnel, and of the varying pathogenic virulence of the "specific" germ, and, probably, of meteorological and telluric factors operating on one or other or both. Accumulation and aggregation of newly arrived susceptible subjects on the one hand, previous experience and diminished facilities for contact, on the other hand, will have very different results, both for the powers of resistance of the host and for the specific qualities of the germ, for the passage of the latter through a series of more susceptible individuals will enhance its virulence and probably enable it to induce pathogenic effects in older and less susceptible subjects. Laboratory experiments and epidemiological experience alike leave little doubt as to the acquisition of powers of progressive infectiveness on the part of the germ under such circumstances, and beyond this it is recognized in regard to other infectious diseases, that the aggregation of patients is associated with specially virulent morbific effects of an explosively infectious character. (Small-pox, Diphtheria.) We may not overlook, furthermore, the possibility of the importation of the germ agent in a stage of virulence which is markedly higher or lower than that of the disease already present or precedent. Infection spread by direct contact may be expected to be more virulent than that derived from a edmiate focus after a longer or shorter saprophytic term of existence. Sometimes the germ requires for effective attack contributory traitorous assistance on the part of the host, in some derangement of the tissues with which its affinity lies, or of the system generally; at other times it gains access in such quantity and virulence as to overcome unimpaired powers of resistance and so to induce the disease even where the favouring conditions are absent. We have therefore to beware of a too definite and arbitrary appraisement of so-called "causes" (Chapter III.); the relative force of the factors in operation varies in time and place, with more or less rhythmical or irregular alternations or combinations of the factors.

In conclusion, it is desirable to emphasize the value, for the elucidation of our problem, of the study *of Comparative Epidemiology*. In the course of the discussion we have drawn on the more salient analogies presented by other contagious diseases in illustration of the argument, but, did space permit, much more could be said in this connexion, both by way of analogy and of contrast. It must suffice to direct attention to the key herein provided to many of the epidemiological problems, the effectiveness of which will vary with the extent of our knowledge and application of the broad principles of biology in its widest sense. The tendency to the "compartment" view is as marked, and the results are as fallacious, in the study of disease as in that of history, and the rapid development of bacteriological science, with its doctrine of specific germ "causes," has served to enhance it, with the result of limiting alike our conceptions and our progress.

From the point of view adopted in this essay in regard to the etiology of Enteric Fever in India, all comparative studies must centre round the question of contagion and contagiousness. We must distinguish between direct and indirect (mediate) contact, and the sense in which the latter term is here employed has been fully explained. Now whether a disease be directly or indirectly contagious, or both, will depend primarily on the nature and biological faculties of the micro-organism in causative association, and on the modes of its propagation and dissemination. An infection due to a strictly obligatory parasite can usually be transmitted by direct contact only; the less parasitic and the more saprophytic the organism, the greater the chances of infection by indirect contact. We have, therefore, to regard the relative faculties of the same and of different disease germs for viability on the double life-stage, *viz.*, within and without the body of the host: with the faculties of the germ, account must be taken of qualities of "soil," anthropic and ectanthropic. On this view, the most prevalent infections may be ranged in the order in which contact plays an essential part in propagation and dissemination, with syphilis, gonorrhœa and rabies at one end of the scale, on to small-pox, glanders, diphtheria, tuberculosis, actinomycosis, Enteric fever, cholera, dysentery, anthrax and tetanus. The last named is hardly ever directly or indirectly contagious, the agent being a vigorous and wide-spread saprophyte, and it is generally acquired independently of any previous case. But even as regards the first on the list, due to obligatory parasites, we know that mediate infection comes into play, as by contaminated drinking vessels (syphilis), clothing, towels, &c. (gonorrhœa). And, then also, we have malaria, formerly relegated to a class of purely *infective* (non-contagious) diseases, the parasite of which, so far as is known at present, fulfils its life cycle in two different hosts, and being a pure parasite, it is only transmitted by contact of the alternative hosts. Other infections will fall into position in the scale and link the series closer.* Their relative positions in the list of contagia will necessarily vary under different circumstances of time (season) and place and of the character and life-conditions of the human community, as affording the conditions for the saprophytic and parasitic stages, respectively. We can only distinguish degrees of contagiousness depending on the foregoing considerations, and for the rest, the epidemiology will be determined by the natural modes of propagation; the means and extent of escape of the virus from the body of the host; its viability and virulence and distribution in external nature; the modes and portal of access to fresh hosts, together with the dose required to renew the infective process.

These considerations not only provide a key to the epidemiology of the different diseases individually, but the results in one case will, by comparison, serve to elucidate the facts

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* NOTE.—The position taken up here in regard to the lessons conveyed by the study of comparative epidemiology is well illustrated in the critical summary of the epidemiology of Plague in India, which is given by the Sanitary Commissioner (India) in his Report for 1904 (pages 91-110). We would refer the reader to the remarks on "regional distribution" (page 96), "local immunity," and "strains of plague" (page 98), the "spread of plague" (page 99), "etiology" (page 101), "climate" (page 103) and "measures" (page 104). The argument is replete throughout with lessons and indications that apply with more or less direct force to the particular problems dealt with in this Essay. As in the case of malaria, we have alternative hosts, the rat and man, but the parasite can certainly maintain its viability in external nature. The epidemiological problem is thereby complicated, but will be elucidated by the application of our formula: the period of incubation and of infection, the means and modes of dissemination, and the number and character of the susceptible hosts (rats and men) and their mutual relations.

in another by analogy or contrast in accordance with the operation of similar or varying factors. Their approximate position in the list would at once suggest analogies in the epidemiology of Enteric Fever, tuberculosis and diphtheria, and to some of the most marked of these attention has been directed, but apart from certain salient details, it is helpful to keep the broad considerations in mind. (See also remarks on cholera and plague in Chapter IV.) For, after all, our interests are not merely speculative, but practical, and our conceptions of contagion and contagiousness must direct and control our measures of prevention and suppression. The position may be stated in simple terms: contagious disease may be transmitted from A to B direct, so that B cannot be infected without A; or from A to B through an ectanthropic body X. In the first case, to save B, we must remove or destroy A. In the second case, we have not only to deal with A, but with X also; to remove A is generally but an imperfect safeguard, and it is, as a rule, impossible to destroy X entirely, though both measures are imperatively indicated. This, in fact, is the situation to be faced in the case of Enteric Fever in Indian cantonments. While, therefore combining these measures of direct attack on the sources of infection to the utmost of our ability, we must fall back on general measures of defence directed to maintain the powers of resistance, *i.e.*, to destroy the "soil" or modify it to a quality unfavourable to the seed while at the same time striking at the seed in its ectanthropic foci.

And thus our last word on the problem brings us back to the starting point in indicating the prime importance and central position of the host, as the source of, and the "soil" for the infection. No facts are more obvious than those of predisposition and immunity; they are detailed if not discussed in every Annual Report, but it can scarcely be said that their practical significance is adequately estimated; they appear to possess a merely abstract interest. We may, however, illustrate their bearing in connexion with the comparative epidemiological standpoint and we take the case of venereal disease as having apparently no very close association with Enteric Fever. In the Annual Report for 1894, the Sanitary Commissioner (India) gives statistics which, as that authority says, reveal the fact that of the 70,642 British soldiers "present" on 15th July 1894, only 37 *per cent* had never suffered venereal infection, while 63 *per cent* had contracted it in some form or other, at some period of their service. Further, he shows that, including other than first admissions, a number equal to 71 *per cent* of the total had entered hospital for some form of venereal disease, since their first arrival in India. These facts demonstrate the much greater susceptibility of the men to venereal infections than to Enteric Fever (see Chapter III.), but in other respects, the conditions which favour infection and propagation are very similar in the two cases. The age-constitution of the personnel and the short-service system, with all it implies, are equally potent factors in the results from both diseases ; the men, themselves, are the chief sources of infection for their fellows, and the mode of infection is by contact with foci, which the conditions of army service render common to large numbers of the community. The epidemiological results must obviously be similar in the two infections, with minor variations corresponding to the nature and force of the factors in operation ; but they must differ very markedly from those observed in the civil community as a whole, wherein the proportion of married adults is much higher, and a system of conservancy with separate water-closets with immediate removal of excreta is the general rule.

It is equally obvious at the same time that meteorological and ectanthropic physical conditions will operate very differently in the two instances, because in syphilis we are not aware of any saprophytic life-stage of the virus, the nidus of infection being the body of the host, with its constant and equable temperature in all latitudes and the protection it affords from the vicissitudes to which external natural objects are subject. Meteorological influences can in this case only affect propagation in an altogether minor degree, by influencing the virility and habits of the individuals who are likely to incur contact with the source of infection. This contrast is alone sufficient to indicate that in Enteric Fever we must look for the operation of these influences, not only on the prospective host but on the virus in its ectanthropic stage of existence.

We have, then, to take account of a natural resistance to infection, which is relative, and subject to increase or decrease according to circumstances, which may affect the system generally, or induce or obviate a *locus resistentiæ minoris.* Both predisposition and immunity depend on intrinsic cell properties, and on extrinsic conditions reacting on the body and its tissue processes, and the natural means of defence may be enhanced or depraved. We need only refer, in direct connexion with our subject, to the varying conditions of the bucco-gastro-intestinal tract ; to the degrees of sepsis that prevail in different sections thereof; to the amount and quality of the gastric juice and other ferments; to the age and quality of the protective epithelial lining and to the effects of irritation and of inflammatory lesions to which it is subject. And as regards more general influences in operation we may note those of age, the amount and quality of the food, fatigue and mental depression, exposure to heat and cold, functional and other disorders, all of which are enhanced under the conditions of army service in an alien environment. By all these means natural resistance to infection can be reduced, and if in a community, of which the normal individuals are insusceptible, a certain number are rendered susceptible by one or other of these causes, the disease once introduced, may then become extremely contagious. And, herein, we may find factors which operate to contribute to the phenomena of endemicity.

Along with these more general influences which disturb adjustment, there are, as previously pointed out, others of a special kind in co-operation locally, and these are bound to be exceptionally frequent and potent in a tropical and insanitary environment. Among these are the graver functional disorders of certain organs which appear to have a protective rôle in the economy, *viz.*, the spleen and the liver when affected by malaria; and again, the effects of the constant ingestion of ordinary filth, largely fæcal, and of the micro-organisms of putrefaction in dust and with food and water. These are calculated not only to produce disorder *sui generis*, but in the form of mixed infections, to enhance the virulence of the specific virus and to open the way to its inroads; there is also the probability of the evolution of "specific" properties on the part of these common ancestral forms. These, then, are the salient considerations which must be applied along with the historical and epidemiological experience and the more precise scientific evidence obtainable in each particular case. With the growth of knowledge we have been enabled to descend from the clouds of vague conjecture, the first nebulous condensations of the primitive conceptions which traced epidemic disease first to the angry intervention of the gods and later to occult cosmic processes; the revelation of the parasitic nature of infectious disease has brought us to the point of regarding man himself, the host, as the central factor in the etiology and epidemiology of the contagions, which amounts to a complete reversal of the standpoint. And herein too may lie the danger of a too narrow view of the indications; while segregation and disinfection are of all measures, most essential and indispensable, we must still preserve and apply the truth that lay concealed in the older views. And when we come to extract this for practical purposes we find its justification in the operation of those general agencies which are connoted by the term "unsound hygiene," personal and social, and the physical environment as affected thereby. In a word, no efforts at prevention can be considered scientific that omit the considerations embraced in the term hygiene, in its widest sense, personal and public. This conclusion may be deemed as trite as it is vague, but it has still to be grasped in its full significance and we must insist that, in regard to the campaign before us, the old adage must be applied in a new form,—"*de minimis curat scientia*,"— for, indeed, there can be no distinction of small from great in the scientific apprehension of the problem.

CHAPTER VIII.

Enteric Fever among Natives of India, and of other Tropical and Sub-tropical Countries.

[In two Parts.*]

We have now to discuss an aspect of our subject, the importance of which is not likely to be underestimated, for apart from its intrinsic interest, the general consensus would regard it as the crux of the problem, the terms of which have been set forth in the preceding chapters and which it is our object to elucidate. The majority of those who have given attention to the main question of the etiology of the disease in the European army in India would be content to rest upon the proposition that if Enteric Fever be a common disease among the native population, there is little more to be said as to the sources of infection, and that, consequently, the hope of prevention lies chiefly in the direction of measures calculated to annul the danger at its source while precluding all risk of contact therewith arising from intercommunication between the two communities. The bare statement of this position demonstrates the gravity and hopelessness of the task, but, fortunately it is one to which the evidence does not compel us to subscribe. Should the common prevalence of the disease among the natives be authentically established, it will certainly add to our difficulties and responsibilities, but however that question be ultimately decided, the writer would appeal with confidence to the facts which prove conclusively that the infection, as it appears as a lamentable scourge of the army, is bred among the troops themselves within their own immediate environment. That there are sources of primary infection in the extra-cantonment environment it is by no means intended to deny; the question remains as to their origin, abundance and frequency, and beyond this, while appraising to the full the

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* This subject will be discussed in two parts; the first will deal with general considerations that have a bearing on the relative immunity of natives to the disease; in the second part (Chapter IX) the evidence will be detailed and analyzed.

danger of infection thus incurred, we have to distinguish between the primary and secondary results.

At the outset it must be averred frankly that the evidence to be dealt with comprises a very small modicum of the sound bread of fact diluted with an intolerable quantity of the sack of vague opinion of very varying, and mostly of doubtful, value ; it is, however, impossible to disregard the latter altogether, inasmuch as the former does not suffice for a conclusive judgment in any other respect than that of the actual occurrence of the disease. In so far, it must be regarded as a great step in advance when regard is paid to the course of opinion in its oscillation between the extremes of negation and of the wholesale assumption of universal prevalence. Just half a century ago Ewart described cases which came under his observation among prisoners in the Ajmere Jail, from which pathological specimens of Enteric ulceration were obtained, which are now preserved in the museum of the Calcutta Medical College. These observations were published at the time, and thus the attention of observers was early drawn to the fact, and it is therefore the more striking that they have awaited confirmation for so long, and that the general consensus of clinicians continued to be in favour of the negative view, or at most was dominated by scepticism. That acute and accomplished physician Norman Chevers recorded his belief that he had never seen a case in a pure native of India, and much more recently Crombie, as the result of his very extensive experience, propounds the view that natives enjoy such a measure of immunity from the disease as to render its occurrence very rare among them. This, indeed, may be taken as representative of the opinions of the great majority of medical officers whose daily work brought them into closest contact with the native sick ; they would not deny the occasional occurrence of the disease, but it was, and is generally, held to be so comparatively rare as to constitute a very exceptional event.*

It has been pointed out that two factors at least have operated to this result ; firstly, the great difficulty in differentiating with certainty by clinical observation between

* The reader should consult Sir J. Fayrer's article on "The Climate and some of the Fevers of India" in Allbutt's *System of Medicine*, Volume II, 1897, notably the sections devoted to Remittent Fever and Indian Enteric Fever. It should be noted that the summary of opinion on the etiology of the latter disease is based on experiences derived from the European troops. For the bearing on the present argument both sections should be read.

Enteric on the one hand and Malarial Remittents, Pneumonias, acute Tuberculosis and other forms of "Continued" Fevers (*e.g.*., that associated with the Leishman-Donovan body) on the other hand ; and, secondly, the rarity of *post-mortem* examinations made in fatal cases among the general population resorting to the hospitals, and in those among the native troops. There is undoubted force in this contention, but it must not be pushed too far ; the great intrinsic interest of the question and its bearing on the problem in the European army have served to concentrate the attention of a new generation of medical officers who have not been under the domination of the older pathological doctrines in regard to Tropical Fevers, and whose sphere of work among the natives has constantly been extending. The question has long been debated by advocates of the two opposing views, and every incentive has been aroused to find a solution to the riddle of the pathology of the prevalent and troublesome group of Remittent and Continued Fevers. Observations have constantly been directed by the view of the possibility of their true Enteric origin, but clinical and *post-mortem* evidence of a definite and positive character has not been forthcoming in support of, but has rather accumulated against, the idea that the infection is common and widespread. It must be noted that although autopsies are rarely obtained in certain classes of the community in comparison with the vast amount of clinical experience available, yet the actual number of fatal cases so examined is, in the aggregate, very large ; the great majority of the two to three thousand fatalities that occur annually in the jails of India are submitted to careful *post-mortem* scrutiny and at least an equal number of examinations are made every year for medico-legal purposes. On the other hand, it may be urged that a positive diagnosis based on the discovery of ulceration of the small intestine is by no means conclusive, and may have led frequently to error. The observations of Vandyke Carter and of Murray (in cases of the fatal Remittent Fever of the Punjab) have been alluded to (Chapter III.), and we have also to discount the results of certain forms of Dysentery, especially when entozoa are present, and of the affection associated with the action of the Leishman-Donovan body, to mention only two instances. It cannot be doubted that under the term "Remittent Fever" several distinct pathological entities have been, and are still, included, among the most frequent being malarial affections, acute Tuberculosis, Pneumonia, Dysentery and the Fever set up by the Leishman-Donovan body, but as regards the estimate of the share which Enteric Fever takes in the mass, we must be guided by the same principles as have served to differentiate these other specific affections, and not be content with assumptions based on their probable exclusion in particular cases as if they represented the full extent of the pathological possibilities. To that end the resources of modern methods of research (notably the serum agglutination test) have been more recently applied, with the result of inducing a decided change of opinion in the minds of an influential minority. To these observations allusion will be made at a later stage in presenting the evidence for the extent of the prevalence of the disease, but it may not be superfluous to sound a note of caution in the acceptance as final of all observations based on a technical process, the essential factors in which are still obscure, and which is not conclusively established as a scientific criterion of universal application. At the same time we have seen a revulsion from the old view on the part of medical officers responsible for the health of the European troops, who, as a general body, have assumed the "saturation" of the native with the Enteric virus to account for the baffling problems of its prevalence in cantonments which have been held to be immaculate in a sanitary sense ; we have dealt with the purely circumstantial evidence on this issue in the course of our argument and shall summarize it in the concluding chapter. It must be granted to have a very inferior value in comparison with that derived from the purely scientific examination of the question, but it certainly cannot be ignored, and if judiciously interpreted, it must carry a great weight of probability against the assumption.

So far then we have two opposing views to be subjected to the tests of the facts on record, but it may be well to preface a brief review of these facts with a few considerations of a more general character. A definite predisposition to, or immunity from, specific infection is dependent on the innate or acquired organisation, structure and function, of the body-tissues in adaptation to the sum of the conditions of life—climate, food, general hygiene and social conditions ("civilization") ; the reaction of the human or animal organism to the disease-stimulus (specific micro-organism) is thus determined, and we have, consequently, distinct contrasts in that reaction exhibited by different races and by communities of the same race living under different conditions ; the general law holding, that given the predisposition and the stimulus, racial immunity is evolved in direct ratio to the experience of the interaction. Apart from the scientific evidence for this thesis, we see that in any one race which is liable to a specific disease, there are the greatest contrasts in the measure of predisposition of its component individuals; *e.g.*, in the case of Enteric, the vast majority even at the most susceptible age-periods are resistant to the infection. Further, in the great majority of any one race the bodily constitution is continually oscillating between different degrees of predisposition or resistance, and it is but a logical step from these facts to the presumption of still more definite contrasts in the susceptibility of different races to the same disease. We need scarcely deal at length with the familiar biological facts which support the empirical conclusions of experience and leave no doubt as to the effective operation in this respect of the factors of race and of environment; we have the case of black and white pigs as presented by Darwin; the great susceptibility of European sheep with the imumnity of the Algerian breed to Anthrax; the selective affinities of the virus of Yellow Fever, the full-blooded Negro being immune, and the susceptibility increasing gradually in the following order: Mulatto, Creole, Southern European, English and Scandinavian; and then the evidence derived from the biological affinities of Entozoa and Trypanosomes. To take a perhaps less familiar instance; we see Danysz's virus ordinarily pathogenic for white mice, but its virulence has to be exalted to affect rats, and this by a specific process for each species of rat; moreover, the virus thus brought to a pathogenic stage for any one species of rat in one locality may prove quite innocuous to the same species in another locality, this resistance being due to subtle changes in the tissues in adaptation to the different environment.

Without attempting to pursue the subject from which many illustrations could be drawn, we have here sufficient warrant for our present purpose of reviewing some of the broader biological conditions affecting the natives which can scarcely fail to exercise an influence, in one way or the other, on the reaction which we call Enteric Fever. By the term natives, it is to be understood that reference is made broadly to the Eastern and Southern indigenous populations, and in particular to the Asiatic, African and mixed races for which some record is available; and as typical examples, we may point in the first instance to the Arabs who come under the observation of medical officers of the French army in Algeria, to the Egyptian fellaheen and Soudanese and to the Japanese. In regard to all these there is a considerable body of reliable evidence to the effect that they enjoy a marked relative degree of immunity from Enteric Fever as compared with the inhabitants of the cold and temperate regions of Northern Europe, when exposed under similar conditions. We have already referred to the recorded experience of French observers in Algerian expeditions to the effect that the Zouaves and troops with an admixture of Arab blood, and in a less degree, Frenchmen introduced from Southern France, have suffered far less from the disease than the troops imported from the more northerly areas.* In a paper contributed in 1901 to the *Archives de Medicine et Pharmacie Militaires* (Vol. 37, page 145) Professor Vincent (of the Val de Grace) refers to observations by Longuet to the effect that native soldiers in Algiers-Tunis hardly ever contract Enteric. He then proceeds to give his own experience at Algiers where the disease is always prevalent among the troops, and affirms that he has seen only one case in an Arab soldier, and further remarks that none of the numerous Arabs who returned from the Madagascar campaign exhibited signs of the infection, though this was common among the repatriated Frenchmen. Vincent was thereby induced to enquire into the facts as experienced in the garrisons of the Algiers division, where the troops are scattered in the towns and outposts, Frenchmen, native Arabs and some Negroes being cantoned in community, the conditions as to age, nature and amount of work and of the environment being identical for all these classes. "In all the garrisons occupied simultaneously by Frenchmen and by indigenous troops the enquiry resulted in entirely concordant evidence. Enteric Fever had a grave incidence, as by a kind of characteristic selection, upon the European element, while avoiding almost entirely the soldiers of Arab race belonging to the same regiments, the same garrison or the same barrack." He then gives a table of attacks, during the period 1890-94, as experienced in the 1st Algerian Tirailleurs, which shows the case-rate *per mille* for Frenchmen to have been 32·3, while that for natives was only 0·44; in the 1st Spahis, the figures were 23·0 and 0·2,

* In this connexion the experiences of the Imperial army of Rome might afford confirmatory evidence; so far as we can judge, these troops were men of medium stature, of dark and olive complexion, like the Italians of the present day. They served under conditions that are found to favour the epidemic prevalence of Enteric Fever, but it may be concluded that they did not furnish examples comparable to the experiences of their modern representatives in the British army.

respectively. Vincent's colleagues and other Colonial medical practitioners assured him that cases were rare amongst both adults and children, though as regards the Kabyles, it was said by some local civil doctors that children are frequently attacked. The serum test (1 : 10, 1 : 20, 1 : 50) was tried by Vincent on 18 Arabs and 5 Negroes ; as regards the former, 11 gave no reaction, the other 7 afforded a slow and incomplete agglutination with 1 : 10 dilutions ; of the latter, 4 gave no reaction, 1 slow at 1 : 10. Vincent sums up his results as demonstrating an almost complete immunity of the Arabs to the infection, and as "in accord with those of Widal among subjects susceptible to the disease." As to whether immunity be natural (innate) or acquired by previous attack he points to the fact that the agglutinating power of the blood does not show itself more often among Arabs (as representing those who possess natural innate immunity), than it is in experience found to persist among others who do not enjoy a natural immunity, but who have passed through an attack. "The reaction is indeed an indication of infection, perhaps of defence, but not one of immunity."

We need not repeat the careful and detailed statement made by Sandwith in regard to the great relative immunity of the native troops of the Egyptian army which is summarized in Chapters VII. and IX. ; it may, however, be recalled that he raises the question of the probability that the rare and occasional cases that arise may be due to community with the European troops in their immediate surroundings.

Lastly, as regards the recent experiences of the Japanese army in the field, we have at present only enough information to show that these have been in very marked contrast to those recorded among our own troops in the South African and other campaigns. It is suggested that much of this relative immunity is due to the careful scientific organization of the sanitary service with the scrupulous care devoted to the purification of the water-supplies, but giving due weight to these considerations, the conclusion cannot be avoided that they account only for a small part of the results, in view of the other important sources of infection in crowded camps occupying sites recently abandoned by an enemy among whom the infection was much more prevalent. Moreover, as regards the deposit and disposal of fæcal excreta, we do not find that the Japanese have risen above our own imperfect standard, while the methods they employ in peace are distinctly inferior in every respect.

Their latrines are on the bad principle of fixed open earthenware bowls, practically small open cess-pools, placed about 3 feet below a wooden platform on which the person squats; from these bowls the excreta are ladled and raked out every second day and carried away in wooden buckets for disposal on the land; this is, in fact, the "pail system" at its worst, with added disadvantages from the fact that the latrine receptacles are never thoroughly cleaned.

We shall endeavour later to supplement the evidence furnished by these instances with the results of enquiry into the experience of other native races living in the tropical and sub-tropical belt, the tendency of which, on the whole, is to confirm the general conclusion that we have to recognize the existence of a decided measure of immunity in contrast with the experience derived from Europeans.

It is, therefore, advisable and even necessary to state as briefly as possible, the fundamental considerations of which account must be taken in an endeavour to trace the factors which operate to produce immunity; exigencies of space require that this statement be made as far as possible, in the form of a summary, and only the broader epidemiological aspects of the subject can be dealt with. The writer disclaims any pretension of establishing, precisely and finally, either the measure or the causes of the relative immunity as to which the evidence (given in detail in Chapter IX.) appears to leave no doubt; the data at disposal are not only inadequate (especially in regard to the prevalence of the disease among children) but in many respects untrustworthy, and our object must be to map out roughly an unexplored region for further scientific research.

In the first place we must have a clear definition of the disease process and we may avoid repetition by referring the reader to the opening pages of Chapter III., the points to be grasped being that the causes of all diseases are prefigured in the molecular structure of the tissue cells—in the potential energies of protoplasm—and that these potential energies become converted into kinetic energies (symptoms) under the influence of disease stimuli (the virus), both tissues and stimuli being subject to the varying influences of the environment. (Hueppe.) Disease is, on this view, a reaction, the function of the sum of all the co-operating factors set forth, and not of any one of these *per se*, and the drama of life and death as a whole takes the form of a struggle towards adaptation to the prevailing local conditions, on the part of the two protagonists.

We postulate, then, in the case of infectious disease, the presence of (*a*) more or less susceptible hosts; (*b*) the effective parasite in sufficient force and amount; (*c*) the means of access of the one to the other.

The question which arises directly from this statement is the problem before us :—to what extent are the conditions fulfilled in regard to Enteric Fever in the case of the natives of India ? Are they in contrast to Europeans in respect of a predisposition to the disease; do they exhibit a relative immunity ? We shall assume the truth of the affirmative reply pending a detailed examination of the evidence. Next, is the parasite, in its effective form, widespread in the native environment ? To this we must say, provisionally, that if regard be paid to the general association of the disease with fæcal filth to the habits, and the primitive conditions of life of the people, including the most defective conservancy, the virus, if present, should be as widespread as that of tuberculosis in Europe. We say "if present" and do not deny the force of many considerations that would point to the probability of this, but we are at once faced with the fact that, if present and if widespread, the results are in strongest contrast with those arising from like conditions elsewhere, if only the combined "fever" mortality be invoked,* and so we are brought back to the first question of a relative immunity and of its causes. It is begging the question to point to the excessive prevalence of the disease among the European troops in India as decisive of the point at issue; at various stages of the previous discussion evidence opposed to this assumption has been adduced, and perhaps the most cogent of all (that derived from the incidence of venereal disease) will be set forth in Chapter X. But we may also note that the European troops suffer very much less from dysentery than natives, a point of importance in view of the similarity of the etiology of this affection to that of Enteric; the virus of dysentery is very widespread and the white immigrants should be more susceptible to it than natives, but the results in the latter case do not support the assumption in the former (Enteric).

* This will not of course measure the extent of *non-fatal* Enteric, but if there be a large amount of this, it merely throws us back on the question of the causes of exceptional resistance (power of recovery) on the part of the natives.

On the question of the means of access of the virus (if widespread) to the host we need say nothing, as no circumstances could be more favourable.

Now both predisposition and immunity vary in extent from the relative to the absolute in different races and in different individuals of the same race; each depends on (1) intrinsic tissue-cell properties, innate or acquired, and on (2) extrinsic conditions reacting, harmfully or favourably, on the body and its functions, either locally or generally, or on the parasite, or on both. Nothing is more certain than that individuals of the same race vary greatly in their reaction to the same disease stimuli; and that the same individuals, again, vary in their powers of resistance in respect to place and to time and season. Only a very small proportion contract Enteric even at the most susceptible ages. The phenomena must be far more definite, the contrasts greater, in regard to different races, in different environments. We can scarcely overestimate the influence in these results of the host factor, *i.e.*, of the bio-chemical constitution of the tissues. For example, it is well known that when measles was introduced into the Polynesian islands the mortality at all ages of the population was appalling, but it is not equally fully recognized that the victims died not nearly so much from the disease itself (quality of the virus) as from the *sequelæ* which took the form of the most prevalent local diseases, *e.g.*, bowel-complaints. (Davis, *B. M. J.*, May 18th, 1894.) The disease, *per se*, was not notably, *i.e.*, directly, fatal, but it altered and lowered the powers of tissue resistance; see also the effects of famine on the fatality of fevers and bowel diseases in India. And a similar conclusion is forced upon us in other cases; the fate of a man and of a race depends upon innate powers of resistance, in all degrees from least to greatest, in the promotion of which a "specific" virus may or may not take its part.

We may now endeavour to classify and distinguish the established facts in regard to immunity from the epidemiological standpoint, while denoting the inter-relations of the different forms. In the first place, we know that non-fatal attacks of certain diseases afford protection from further attacks, whereas other infections render no such advantage to the individual victims. The different forms of immunity may accordingly be classified as follows:—

I. "Acquired" or personal, and II. "Innate" or racial; and we shall have to distinguish the operation of different factors under each head, though, as will be seen, the influence of these factors cannot be restricted to the category with which they are associated primarily.

I (*a*). Individual or personal immunity, derived from successful resistance to an attack at any age ; but this has a special bearing on our problem when the protective attacks occur in childhood, and where the great majority of young children suffer, as it is obvious that the adult community will thereby derive a greater or less measure of protection. It will also be clear that, in the case of a fatal disease, there will be additional results in the promotion of a true racial immunity by the elimination of the least resistant before marriage and, consequently, by the non-transmission of the predisposition to offspring, while the resisting powers of the survivors or of the naturally immune will be so transmitted to a greater or less degree. We should expect that attacks would be exceptionally fatal in those who escape the disease in childhood, *i. e.*, there should be a high case-mortality.

I (*b*). Personal immunity may also be acquired by the constant ingestion or imbibition of doses of the virus which do not avail to induce an attack; this influence will operate chiefly on those who possess some innate measure of resistance, or on more susceptible subjects living under otherwise favourable conditions.

This form of immunity is frequently lost on departure from the place where it is acquired and it corresponds to that which may be induced experimentally in animals by feeding them with the disease-agents or their products. (Snake venom; dust infection). It also presupposes the widespread prevalence of the virus in the environment, or, possibly, of the virus of other allied filth diseases, experience of which promotes a local resistance of the tissues with which they come into contact.

II. Racial, or innate immunity, which may be due (*a*) to the elimination of the non-resistant, (unfit), and to the survival of the immune, or of the resistant, who transmit their powers to their offspring, and which will be the more effective in proportion to the youth of the victims. This must operate, in different degrees, in all fatal forms of disease in proportion to their fatality and to their prevalence, see I (*a*), but is usually most marked in regard to infections, one attack of which does not afford protection in the future (malaria, tuberculosis, &c.). It may be said that in time such a racial immunity might be expected to become practically perfect, if the conditions were allowed full play, while adequate means were taken to raise the resistance of the race in other ways,—restrictions on marriage, by diet, and general hygiene. It is otherwise in the case of infections, an attack of which affords protection ; here the innate power evolved is that of the power of recovery rather than of immunity to attack, for such diseases continue to maintain their prevalence undiminished (not their fatality), save where we are able to strike effectively at the sources of infection (compare measles and Enteric Fever under modern sanitary conditions). It may be noted that this form of immunity (racial and innate) may be absent in many individuals of an otherwise immune race owing to reversion on their part to a previous stage in the phylogeny anterior to the evolution of the corporate immunity. We should expect that attacks would not only be rare, but would ordinarily furnish a low case-mortality, save in the case of such reversions which may be more frequent than is commonly supposed. In this connexion we have to take account of the remarkable contrast in the blood-purity of races and stocks in India and the West, respectively, owing to the endogamy (qualified, but still marked and potent) and the isolation in small close communities in the former, and to the much freer marriage-customs and cosmopolitanism which prevail in the latter. Every man in India has a pedigree of untold length and of perfect purity, so far as "purity" connotes the absence of admixture of foreign blood or of that of a different stock or caste. We may possibly find in this blood-purity a condition which accounts for many of the characteristic features of the Vital Statistics, and notably the excessive mortality from specific infectious diseases, as well as light on the problems of heredity.

II (*b*). Or racial immunity may be due to general conditions of life and their impress on the structure and functions of the organs and tissues, with results in the prevention of the specific disease reaction. That is, there may be a lack of adaptation on the part of a specific virus (micro-organism) to the tissues of the host and to the maintenance of a parasitic life-stage thereon; the key does not fit the lock. The germ does not find conditions in the "soil" favourable to variation towards pathogenetic virulence, and so is not evolved to a higher pathogenetic grade. Such general conditions may be found in the occult qualities of race, and in the influences of climate, food, and other prevalent diseases, as well as in the stage of civilization attained. These influences may well co-operate with others which induce a personal immunity [I (*b*)], so that it will be evident that we can look to no one exclusive factor, and that our classification does not bear an arbitrary interpretation and application. This second suggestion of the influences which may determine racial immunity receives support from the terms of our definition of the disease-process, and, in its epidemiological effects, it has certain affinities with those to be expected from the acquired form, I (*b*), when a large and varied population is equally exposed to the factors in operation. The processes are certainly neither antagonistic nor alternative; on the contrary, we must recognize a probability of a co-operation of the processes of adaptation, *viz.*, that promoting an inherent, physiological insusceptibility and that which enhances the property of resistance by constant experience of the virus or its near allies, which is as potent for the cell or local tissue as it is for the individual (see later).

We should now be in possession of a key to the problem before us, and we may forthwith express the opinion that a combination of the several factors must be in co-operation, and that not one can be excluded from account. We must remember, when contrasting the innate traits (II category) with the use-acquirements (*e.g.*, 1 b) that the latter depend also on inborn traits developed by Natural Selection, and we have referred to the distinct phenomenon of the evolution of the power of *acquiring* immunity. In our application of the tests we must not be diverted by the force of any one consideration; *e.g.*, if children were proved to suffer from the disease, it would not necessarily account entirely for adult immunity. The number of cases of Small-pox which occur in infancy in India is quite inadequate (even with the aid of vaccination) to explain the comparative freedom of adults when all the circumstances, including the widespread prevalence of the infection, are regarded. Characters which appear late in the ontogeny are not necessarily acquired. And, again, in the use of the case-mortality test, which will give opposite results in categories I (*a*) and II (*a*), we have first to be sure of our data. In the statistics for the Native Army and the Prisoners, it will be found that the case-mortality, as recorded is very high, and we have to satisfy ourselves first as to how far non-recognition of the disease may discount our inferences.

But at the same time if we allow fully for this and assume the fact of a low fatality rate, there will still be left a very ample margin to establish the fact of relative immunity in a high degree. It is, however, notable that where the diagnosis has been confirmed by scientific methods in capable hands, the case-mortality is found to be lower, though, indeed, such cases are comparatively few. We have also to take account of "reversions" (in the case of inborn immunity) to a previous stage of susceptibility. We may now proceed to review the evidence, and shall deal first with the considerations which bear upon the promotion of an inherent physiological immunity in the race.

Regarding the problem from the broadest biological standpoint we must recognize that the process of adaptation, which is constantly in operation, is determined by four main influences, *viz.*, climate, diet, the stage of civilization and the most prevalent and fatal forms of disease. These combine to mould the organism and to determine its specific qualities, structural and functional, and, consequently, its reaction to the chief eliminating forces under which evolution proceeds. In the case before us, climate as represented by its predominant factors, high and sustained temperature and abundant and powerful sunlight, is recognized to affect, markedly, the structure and relative physiological adjustment of the skin and the abdominal organs. Although the temperature mechanism in warm-blooded animals is adjusted to a great range in different climates, the inhabitants of the tropics are adapted to heat, in contrast to those of northern and temperature regions who are adapted to cold, and the results are seen in the relative extent and character of the morbid influences which affect the different races at different seasons in their respective habitats, or when both are alike exposed under similar conditions. (See Statement, Chap. IV.) We cannot ignore the evidence of a contrast in the balance and correlation of function of the vital organs in the two cases, which must affect the natural biochemical forces of resistance. Long ago de Quatrefages pointed out that the cutaneous glands and their function are more highly developed in the Negro than in the white man, and Pruner Bey (Egypt) asserted that the same fact holds good for the intestinal canal throughout its whole length. However this may be for other tropical races, we scarcely need coarse physical signs to assure us of definite structural and functional contrasts; it may be added that the writer has endeavoured to obtain evidence on this subject from the authorities in charge of the anatomical schools in India, but the observations kindly instituted on this account are at present too few to permit of conclusive generalization. Dr. Beli Ram, Rai Bahadur, of the Lahore Medical College, who has an experience of more than 2,000 subjects in the dissecting-room, informs me that the large and small intestines are considerably longer in a large proportion of cases than the normal average for Europeans; that the intestinal walls are thicker, and more muscular, and that it is difficult to find typical specimens of Peyer's patches for demonstration. In 7 out of 41 observations recently made, the small intestine varied in length from 31 to 45 feet, while in 11 the large gut ranged from over 7 to 10 feet in length; one Muhammadan male had an intestine (large and small combined) 50 feet long, and two other cases were noted in which the combined length extended to between 40 and 50 feet. The vermiform appendix (28 subjects) was found to vary between 6·5 and 1·5 inches in length.

This brings us obviously to the second influence, *viz.*, that of diet, on the structure and function of the bowel and of the other intestinal organs and the tissues generally. The diet of modern civilized communities in the West has a "chemico-physiological" character; there has been an increasing tendency to supply the individual food elements in a concentrated, assimilable and mixed form, together with an ever larger proportion of animal food and with an excess in the total ingested over physiological requirements. This must connote a corresponding change in the structure and function of the digestive organs, in the evolution of the absorbent tissues, and a degeneration of the muscular and masticating apparatus; possibly also grosser anatomical alterations of the intestinal tract which must react upon the other organs and the tissues generally. In a large proportion of the individuals of a modern civilized community, especially in larger urban centres, the digestive tract is disordered from one end to the other, with decay or absence of teeth and degeneration of salivary glands setting up sepsis in the mouth, with dyspepsia and intestinal derangements lower down, for the relief of which drugs are constantly in requisition and for which the penalty is paid in the prevalence of appendicitis and other critical diseases which have contributed to the rise of modern surgery. The digestive processes comprise an organically connected and interdependent cycle or sequence, the failure of any one of which entails the risk of failure throughout, the intestine necessarily bearing the brunt. The case is altogether different with the diet and dietetic habits of more primitive races in rural communities; the bulky coarse cereals and pulses, with a large content of cellulose, demand altogether other anatomical and physiological attributes, and notably as regards the fullest demand on the masticatory apparatus and the muscular development of the intestinal walls; the same features are, indeed, to be observed to some extent in children of modern Western races, with which also their instinctive dietetic prejudices are in keeping. With the alteration in diet and the degeneration of the mechanical apparatus for the attrition and movement of the food, together with the too frequent call upon digestion, we see the prevalence of torpor and constipation, and conditions are set up which transform the lower bowel into a cesspool; more or less solid fæces are found in the ileum and cæcum which are adapted only to deal with fluid or semifluid residues, and hence arise derangements at a critical turning-point of the tract often involving putrefactive and peculiar fermentative processes owing to the loss of normal control over the micro-organic flora and to alterations in the relative predominance of the different species normally present. (See remarks on "infection from below" at end of Chap. III.)

MacEwen, in his Huxley Lecture for 1904, has discussed the important points connected with the structure and function of the cæcum in relation to diet; he indicates, by interesting analogies, its rôle as a "compensatory organ to the stomach" with a special application to the digestion and assimilation of cellulose, and he gives weighty evidence to show that the arrest of its function involves local disturbances in the tract above and below, with more general results in wasting and inanition. The cæcal *succus entericus* is a powerful adjuvant to the completion of the digestive process and controls the character and function of the micro-organisms which play their part therein; and in concordance with the views of Sanarelli (see Chap. III.), he points to the loss of this control as providing conditions for the pathological action of the *b. coli,* with consequent fermentation resulting in damage to the intestinal walls and the absorption of toxins.

"Primitive man had to search for his food, and sometimes he had a hard physical fight to get it. When he found it, as he had been looking forward to it, he was fit for it and enjoyed it; consequently, he had an abundant flow of all the digestive juices which were ready to receive the food and give it a warm welcome. Present-day man is said to be in an evolutionary stage. With his indoor occupations and his ever-engrossing mental pursuits, he forgets that he has to live, and that in order to do so he has to eat and digest, and that his duty to himself and to the community is to do both well in order that he continue in health. But, from the way prevalent in many places, he seems to act as if food should be thrown into the stomach, as a sandwich into a pocket, and the lid closed. Then he wonders that he has indigestion and appendicitis."

With a marked difference in the character of the diet, we must, therefore, expect contrasts in the nature and biological properties of the micro-organic inhabitants of the tract and in the structure and function of the latter, which cannot fail to affect the reaction to disease stimuli. In regard to the lymphoid tissues especially, so directly implicated in Enteric infection, we cannot but assume that they come under the moulding influences of adaptation, that they will be more highly developed and subject to derangement under one set of conditions than another; and, for example, the relative immunity of Southern and Eastern races to Scarlatina and Diphtheria may have some definite relation to the fact that the tonsils are, as a rule, less developed and less subject to derangement than in the "lymphatic temperament" of Northern Europe. Whenever an organ or tissue becomes stronger by exercise, it must possess a degree of importance for the life of the individual, and so it becomes subject to alteration and improvement by natural selection, for only those who possess the organ in its most perfect form can reproduce it; but with this factor of exercise and use, we have the original quality of the predisposition of the germ plasm to produce a more perfect organ. Any change in the habits of life,—work, diet, climate,—will modify function and so structure, and thus by selection (through disease and failure of adjustment), will evolve different types and powers of resistance, *i.e.*, of adjustment. The struggle does not cease with the foundation of some new specific type, or with more perfect adaptation to the external or internal conditions of life; it becomes more severe, so that the *most minute differences of structure* may determine the issue between life and death.

In a very broad comparison of the staple dietary and the associated habits of modern Europeans and the Natives of India, the following characteristic points may be noted: the food is for :— (see next page)

The Native.	The European.
Cold and dry.	Hot and fluid.
Bulky and coarse; much waste.	Concentrated and soluble.
Vegetable grains; Cereals and pulses; large cellulose content. Low proteid and Fat content.	Animal food, with high proteid and fat.
Very partially cooked, plain and monotonous from day to day.	Thoroughly cooked and sophisticated. Very mixed and varied.
Meals infrequent; twice daily with long fasts.	Meals frequent, 4 or 5 times a day.
Mastication generally good.	Faulty in extreme.
The majority eat to live.	More often live to eat.
Life and work in open air.	Sedentary, indoor.
Fæcal evacuations twice daily, large, 10-12 oz: completer by squatting.	Small, 5-6oz: constipation rife. Purgatives.
Strain on stomach and large bowel.	Strain on Stomach and small Intestine.

It is impossible to refer at length to the various considerations suggested by this contrast; we may merely recall one or two points in connexion with the conditions that favour, or militate against, toxic putrefactive processes in the intestine; we have the fact that the action of putrefactive organisms present in the intestine is inhibited by the lactic and acetic acids produced in the normal fermentation of carbohydrates of which the food of the Native so largely consists, and as a result of which the normal acidity of the contents of the ileum is enhanced. These acids act along with the bulky food with its large cellulose content in promoting the peristaltic action of the intestinal tract, the results of which are seen in the double daily fæcal evacuation: this increased peristalsis, with the prevention of constipation is one of the chief preventives of abnormal fermentation and putrefaction. The association of a meat dietary and other "animal" food with the production of ptomaines, leucomaines and other toxic products is well established; *e.g.*, methyl guanidin from the creatin and creatinin of meat muscle; and it is a commonplace of experience that carnivora are liable to convulsive seizures from dietetic disturbances, wherefrom herbivora are exempt. We may not lose sight of the fact that the combination of alcohol with a meat diet tends also to the production of auto-toxic putrefaction which must lower the resistance of the tissues to infective agents. In this connexion it is scarcely out of place to refer to the great immunity, enjoyed by natives to pathological psychoses of a toxic origin save in regard to hemp and opium; there are obviously other important factors lacking in the character of the civilization in which the people live, but insanity is relatively rare and this especially as regards the forms associated with intestinal auto-toxication. Lastly, it may be noted that with an actual increase in the size of the intestinal tract in natives, there is a relatively large liver; in 714 observations made at the Lahore Medical College on healthy male subjects, this organ was found to weigh, on the average, 46·5 ounces, which is distinctly large in comparison with that found in Europeans, when the respective average body weights are considered; in the case of the healthy adult native the latter cannot be reckoned at more than 110 lb. It can be shown that in spite of the excessive incidence of dysentery, abscess of the liver is much less frequent in natives than in Europeans, and the same may be said of the functional disorders of this organ, and notably of jaundice. This may be taken to indicate that the liver is less called upon to deal with toxic products engendered in the intestine and is, on the other hand, better able to exercise its protective functions against these when they do arise.

Comparing the recorded incidence of Appendicitis and Typhlitis and of Abscess and inflammation of the liver, on Europeans and natives, during the last 10 years (1895—1904), we get the following results, in mean ratios *per mille* of strengths :—

1895—1904. INDIA.	Appendicitis and Typhlitis.		Abscess of Liver.		Inflammation and congestion of Liver.	
	A.	D.	A.	D.	A.	D.
European Troops	·9	·05	2·4	1·41	16·8	·05
Native Troops	·3	·02	·1	·05	1·2	·06
Prisoners	·1	·02	·1	·08	1·1	·05

The figures speak for themselves, but it may be noted that the incidence of Appendicitis and Typhlitis on the European troops was markedly highest during the years of greatest Enteric prevalence, which does not, however, apply to liver abscess; further, the amount of inflammation, &c., of the liver in 1901—1903, with the higher age and service constitution of the army (European), was reduced to the extent of 20 *per cent.*

Taking next into consideration the contrast in the course and present stage of the civilizations (in the broadest sense) in the two classes, it is impossible to believe that there has not been adaptation along different lines, which cannot but determine a definite contrast in the reaction to the same disease stimuli, and where these are themselves unicellular organic beings we must expect that they will also be affected by the different conditions in regard to their evolution and adaptation to parasitic life with pathogenic qualities. We shall further expect to find evidence that where the vital conditions of the native races approximate more closely to those of modern Western urban communities, as regards diet, habits of life, aggregation, &c., Enteric Fever finds, and makes the most of, its opportunities for development.

There can be no question of the fact of the evolution of the disease agent from an originally harmless saprophyte to the parasitic stage, and in this case, where the extra-corporeal viability is not easily maintained, an abundant population of hosts in long-settled and densely-aggregated communities must be assumed to be necessary to the end in view. The evolution of the disease must have been concurrent with the progress of civilization; with the abandonment of nomadic conditions and the change from small sparse, isolated, scattered and exclusive communities on the land, to the rise and growth of towns with ever-increasing aggregation therein, the sanitary evils involved thereby, and the development of traffic and intercourse; for in these circumstances alone would the human material at risk and the saprophyte be brought into effective relation, while, in course of time, the same conditions in continual operation will result in a more or less effective compromise by the evolution of the forces of resistance through the elimination of the most susceptible individuals. Such communities may become endemic centres which are very dangerous to newcomers, who provide the most delicate test of the presence of infection. Now in regard to India, nine-tenths of the population live in comparatively small isolated village communities, and for the rest, occupying the towns, we have to note certain distinctions in the conditions that governed aggregation before the consolidation of British supremacy, as compared with those prevailing in the West. The towns were comparatively few and far apart and, for the most part, were either court and camp centres or pilgrim resorts, and under the unsettled conditions were never long occupied continuously, or were subject to very temporary occupation. It may be granted, however, that in the absence of other factors which would determine an inherent immunity, the conditions were in many respects not unfavourable to the prevalence of Enteric Fever, and that with the growth of more settled trade and manufacturing centres during the last 50 years, they have become more favourable. If the disease be endemic herein, we ought, therefore, to find an excessive liability thereto on the part of the peasants and the country-bred generally, who resort to the populous centres, by inclination, as in the case of recruits for the native army who number some 20,000 annually, in that of students who come in to the secondary schools, and in that of pilgrims who resort to the great shrines of their faith; or, by force, as in the case of prisoners, the number of whom passing through the jails every year, amounts to nearly 450,000. There ought then to be abundant material and opportunities for epidemic outbreaks, as to which, at any rate, the evidence is conclusively negative.

Further, in the absence of a relative and inherent immunity, we should expect to get evidence of marked contrasts in the local prevalence of the disease in different areas according to the prevailing conditions of civilization; the disease should be more notably prevalent in the northern and continental area where the communities are larger, and the dwellings have always been more closely compacted (by the necessities of defence from political enemies or of marauding bands), and where the worst evils of sanitary neglect are most apparent, than in the south where small scattered villages, hamlets and homesteads are the rule. But this again is not definitely supported by the facts available.

In discussing the question of infection contracted in the bazaars and native towns by the European troops, we found good reason to deprecate the assumption that the disease is necessarily endemic therein (see also final chapter); the evidence is much more in favour of the view of the infection of these haunts by the troops themselves. If it be granted that Enteric Fever is pre-eminently a disease of Western civilization and that it is spread by traffic and intercommunication, one of the first suggestions that must occur is to apply the moral of the history of the spread of tuberculosis, and to enquire whether the facts regarding the incidence of the former disease on the native population bear any relation to its introduction and spread by Europeans. Up to the time of the Mutiny (1857) the country had been the scene of constant war, plunder and confusion for centuries, then peace and settled conditions of life were imposed, and urbanization in the modern sense may be said to have taken its rise. The European invaders had, till then, scarcely occupied the country beyond the coast and adjacent areas, but from this date, their numbers were largely increased, the interior was occupied, cantonments were established in the close neighbourhood of the larger towns, and the age and service constitution of the forces underwent a complete change. Closer intercourse with the native population was rapidly established, both locally, and by the movements of troops up and down the country, by the occupation of camps, rifle meetings, sport, &c. Meanwhile, Enteric Fever was rapidly increasing in the army and the infection was scattered broadcast in its trail; we have seen, however, that in many places now associated with the endemic prevalence of the disease, young and newly-arrived men were not attacked 40 years ago. (Chapter II.) In face of these considerations we have to note that evidence is not wanting of a certain definite increase in the prevalence of tuberculosis among the natives under medical control, and therefore in closest association with Europeans, and further, that the record of Enteric Fever is derived from experience among the same classes, *viz.*, those living in and near the larger centres occupied more or less by Europeans. There is of course the objection that the disease is only likely to be recognized among those who come under competent observation, but we have, on the other hand, the comparative rarity of this recognition, the absence of evidence of epidemic outbreaks in towns and institutions where young adult natives are aggregated, and the general impression derived from the practice of remote out-station dispensaries in rural areas, that the disease is there rare or altogether absent.

It need scarcely be pointed out that, in most important respects, the life conditions and habits of the natives would tend to invite and spread the disease, were the effective agent widespread in their excreta and the predisposition present. Fæcal filth abounds in the environment from the general practice of defæcation on the open soil or in the most primitive house privies, in close connexion with the cooking and bathing arrangements; the close social bond involving the co-occupation of dwellings by several related families, the customs of commensality along with the practices of hand-to-mouth feeding and of "cleaning" the food utensils with the foul soil of the site, and the almost universal contamination of the water-supplies from surface wells (often sunk in the court-yards) provide all the necessary conditions for endemic prevalence of "filth" diseases. And thus in endeavouring to form a judgment on the main question, the negative evidence as to the prevalence of Enteric Fever among the natives must be granted the greater weight in proportion to their obvious neglect of elemental sanitary precautions, while bearing in mind the abundant positive evidence of their great liability to epidemic outbreaks of other "filth" infections, cholera and dysentery. The parallel afforded in the experience of competent observers in Egypt must not be ignored. From the time of Pruner Bey (1834–46) up to that of Sandwith in the present day, Enteric Fever has been declared to be "very rare in natives and Negroes," while resident Armenians, Syrians, Greeks and Northern Europeans have furnished abundant cases, the latter suffering to the greatest extent. And the general result of these considerations is to force upon us the conclusion that the disease would be universally prevalent among the native population unless the specific germ be wanting, or they possess an inherent immnnity, or have acquired it by a process of long experience, in which latter case it is difficult to account for the excessive prevalence of dysentery and cholera, to which as compared with Europeans, they have a greater liability. Different conditions of life and of exposure to the sources of infection must not be overlooked, but these will serve to explain the greater morbidity rather than the relative fatality (case-mortality), which is greater in the case of natives.

Before touching upon the fourth factor,—the adaptation of the organism to the most prevalent disease-causes,—we may return for a moment to some more debatable and abstract considerations on the relation of structure and function to immunity. The theories of Metchnikoff and Ehrlich alike point to the ultimate tissue elements as chiefly concerned in the reaction of the organism to the stimuli of infective agents and as determining the results; although in detail these theories still remain largely in the realm of speculation, we know that, within certain limitations, every organism has special cellular equipment for its protection against infection. For example, the skin acts as an external protective agent, provided there be no solution of its continuity; at the same time it may be overcome by inunction of the infective agent with mechanical pressure. The lymphatic glands act as barriers to the entrance or diffusion of many infective organisms. Intact mucous membranes are antagonistic to most microbes. Large quantities of virulent anthrax spores are required to infect guinea-pigs or mice when administered by the alimentary canal, while small quantities suffice if injected subcutaneously. The acid gastric juice is also protective, as instanced in its prevention of cholera infection. The sensitive ciliated epithelium of the bronchi and the germicidal action of mucus may protect the respiratory organs from tuberculous and pneumonic infections. The age and nature of epithelium are important factors in combating diphtheria, the younger cells being less resistant. Traumatic lesions at the seat of infection will cause a local predisposition to certain infective processes. Malignant endocarditis has been produced by injuring the protective endothelial covering of the valves and then injecting infective organisms, while endocarditis did not take place when the valves were intact. The phenomena of pus formation resulting from the injection of various inorganic substances in different animals, leads to the conclusion that this depends chiefly on the character of the tissue cells rather than upon the material employed. Then again, the amount, the composition and reaction of the body fluids is of importance; *e.g.*, the rat is immune to anthrax largely by reason of the high degree of alkalinity of its blood and tissue fluids. On the other hand, there is reason to believe that a purely vegetable diet (of cereals) may cause a notable diminution of alkalinity (Behring ; Wright's theory of Scurvy). When we approach to a closer analysis of the facts, we are led more definitely to regard the tissue cells as the effective agents in resistance to infection, and this, whether we incline to the purely phagocytic or to the "humoral" theory, and we need refer only to the special affinities which specific toxins are shown to possess for different tissues and to the great contrast in the susceptibility of the same tissues in different animals to the same toxin. But more and more as knowledge grows we find the two theories to be compatible in all essentials, and under the guiding principle that we must look to physiology to explain pathology, that disease is but the liberation of energy already potentially present in health, and that natural resistance and susceptibility are not contraries but correlates, we are led ever more directly to find the root of the problem in the essential conditions of life and the adaptation of the tissues thereto. Of these, as has been said, climate, diet and disease are, by far, the most important ; as regards the first we need not indicate its more obvious influences on the cells and fluid tissues. By means of the diet the tissues are directly supplied and renewed, and come into most direct touch with the environment, and Ehrlich's theory is based fundamentally on the function of the ultimate tissue elements in regard to nutrition; the same "receptors" react both to food and to toxin molecules. But inasmuch as these receptors must vary in their adaptation to different food molecules in accordance with the nature of the staple diet, and in view of their varying affinities for different specific toxins, we may at once recognize that marked contrasts in diet will involve different disease reactions and varying grades of immunity or predisposition to the same agents. The nutritive receptors formed under certain dietetic conditions may have less affinity for certain toxin molecules, or they may have a far greater affinity for the special food molecule.

In different individuals of the same race the cells of homologous organs are supplied with receptors which are not of the same pattern in all cases, and the pattern differs in the several organs, and as a result we see the same infective agent manifesting itself in varying degree of virulence and by very different symptoms in different cases ; *e.g.* in Enteric Fever itself, we may have renal, cardiac or cerebral symptoms predominating over the intestinal disturbance in the clinical picture. In regard to bactericidal immunity, whatever view be adopted of the relative importance of "amboceptor" and "complement," it is obvious that the nature of the food and the specific stimuli of pathogenic bacteria of the "filth" species, are alike important by their action on the composition of the blood-serum and upon the tissue cells. And on Hueppe's view the natural resistance of species and races, as a result of adaptation and selection, must be caused by the presence of immune bodies which are formed by the assimilation of the food. A mixed and varied diet may be expected to promote a more generally effective defensive agency against a greater variety of specific bacterial infections ; a more simple vegetable diet may, however, provide the conditions for immunity against certain infections within a more limited range (*e.g.*, Scarlatina and Diphtheria so rare among natives), while, on the other hand, we might expect an increase of susceptibility to the action of the majority of the pathogenic bacteria.

We shall refer in the next chapter to observations which appear to show that there are notable differences in the blood-albumens of different races of the same species, with corresponding results in the reaction of the blood on foreign bodies submitted to its action.

When we come to study the incidence of Enteric Fever on the different races of India, evidence will be adduced in favour of the view that diet and surroundings appear to determine a certain measure of relative predisposition or immunity to the disease, for, in so far as these approximate to European standards, there appears to be an increased liability.

We have now to take account of the effect on structure and function, and, therefore, of tissue resistance, of the diseases to which a given population is most subject. In the present connexion we need consider only the excessive liability of the natives to diseases of the bowels, an indication of which is afforded by the fact that under the most careful and complete sanitary arrangements as provided in the jails, no less than 20 *per cent* of the total mortality is ascribed to one cause, *viz.*, Dysentery; and this, be it noted, refers to the adult population and represents the present conditions which are a vast improvement on the results recorded formerly; for while the combined death-rate has been reduced in the jails by 30 to 50 *per cent*, the decrease in the share attributed to bowel diseases has been much greater. With this fact before us we have to correlate two other considerations; first, the biological affinities of the whole of what is called the "Coli" group, in which *b. typhosus* and *b. dysenteriæ* of various kinds are included with several intermediate varieties (paratyphoid, etc.), which form links in the chain of connexion *inter se*, or branches of the same original stem; and, secondly, the probable cause of this differentiation by evolution in adaptation to the conditions of life, whereby different biological faculties have been evolved, and we get the pure saprophyte at one end of the scale and the almost obligatory parasite at the other end. This is not to assume that the latter is the direct descendant of the former any more than that man is descended from the ape, a popular error that is more easily refuted in the case of the man than in that of the microbe; both are probably descendants of a more remote and original ancestor. Without impugning the orthodox view of the immutability of species, we may not overlook the possibility that the effects of the reaction of one species on the tissue cells of the host may affect specifically the reaction of another and allied species of the group. In brief, constant experience on the part of the tissues of one species of filth micro-organism or of the ancestral saprophytic form may well evolve in the tissues protective structures and secretions (receptors, amboceptors, and complements) against the effective attack of an allied species, or of the evolved parasitic form, respectively.

We have already referred to the evidence of local tissue immunity, but we have reserved the most striking facts in this connexion for this aspect of the subject. The *b. coli* is not a parasite in the true sense, for it lives ordinarily on dead matter in the intestine where it performs a function in the conversion of the food of the host in exchange for the hospitality it receives. It can only assume pathogenic properties occasionally and under abnormal conditions of the local tissues, when it may invade these and set up inflammatory and necrotic processes, as in Enteric Fever, in which infection its growth and virulence are greatly enhanced—a suggestive fact. But if the same harmless organism be introduced into other parts of the body, which are normally sterile and have no experience of this or other organisms (the kidney, pelvis, ureters, pleural sacs, etc.), we get pathological effects due to the susceptibility of the local tissue cells. On the other hand, the most tolerant and resistant tissues are those which are always in contact with micro-organisms of one sort or another, *e.g.*, those of the mouth and intestinal tract, and where filth bacteria are constantly ingested this power of resistance of the intestinal tissues will be further enhanced; we then see the local tissue immunity against the commonest "filth" bacteria at its highest grade, and where fæcal filth is constantly ingested the local "soil" must be unfavourable to the evolution of higher (more virulent) pathogenetic powers by the germs. And this local immunity increases with age, as seen in the case of the dysentery of calves to which the older cattle are more or less immune, as well as in the diarrhœas of children due to *b. coli.* (Escherich, Heubner, Baginsky.) The same result is observed in the case of Enteric Fever itself, and in cholera and dysentery, for the intestine after recovery can harbour bacilli which are as harmless as *b. coli* to the individual, though effectively virulent to any other susceptible person. Hence the phenomena and the danger of so-called "*bacillenträger.*" This increase of local tissue resistance is most potent against those infections by which the organism is attacked spontaneously and continuously through the ordinary channels of access ; in this way, we may, perhaps, account for the form of immunity conferred by feeding experiments. (Wassermann and Citron.)

All this is obviously consonant with the facts of the immunity of races to disease in proportion to their experience thereof, and we may take it that there is an "acclimatization" of the intestinal structures to filth bacteria wherever these are constantly ingested ; the bacteria themselves becoming insusceptible to the action of the protective substances evolved in the reaction, and hence the explanation of the negative results of the serum reaction in immune races (Arabs), agglutination being a reaction of infection and not of immunity.

The character of the flora of the intestine will be determined by the nature of the diet and of the surroundings, including the general sanitary conditions ; *b. coli* must always be relatively abundant in the circumstances of primitive life with a vegetable diet, in which also other filth bacteria will be more freely and constantly ingested and in which again affections of the colon are most frequent. But these conditions may not be favourable to the evolution of some other varieties of the group, which may only appear in adaptation to altered conditions of life and diet (modern Western civilization); or, on the other hand, the one variety may set up a reaction of resistance to the other and more parasitic type. As Kanthack has said, "recovery from one infection often renders the individual less susceptible to other infections."

Evidence is not wanting in support of these hypotheses. With the altered conditions of life and civilization we see a marked change in the type of disease ; dysentery, the greatest scourge of primitive communities, disappears whilst Enteric Fever and its congeners become more prevalent ; a more or less local disorder (though often complicated by ancillary septic processes) gives place to a more generalised toxic infection—a "fever"—which may be held to mark a higher stage of evolution on the part of the parasite in response to the resistance it meets from the tissues, which, however, are now unfortified by the reaction to the dysenteric microbe. Knowing, as we do, that dysentery is excessively prevalent among the natives, it is difficult to understand, on the theory of the equally widespread infection of Enteric Fever, how Europeans in India escape the former with a light penalty, and fall a prey to the latter disease, save on the ground of some such assumption as is here set forth. And, again, we may emphasize the necessity of guarding against the too facile conclusion that the seed is synonymous with the harvest, for quite as much depends upon the soil, which in the cases before us is essentially different. When, however, we regard the chief causes of morbidity and mortality to which European infants are liable, we see therein an indication of like effects from like causes ; the diet and the other conditions of life at this stage approximate closely to those of all ages in the East,—a repetition of phylogenic conditions in the ontogeny—and we see the results in an excess of diarrhœa and dysentery, as to the character of which, as distinct from Enteric Fever, there is little doubt, though it is not contended that many cases of the latter are not overlooked.* It has been said that the greater susceptibility to Enteric, exhibited by the European troops in India in recent years, is due to the lack of protection acquired by attack in infancy since the results of the sanitary era in England have become manifest, with an assumed consequent diminution in the prevalence of infantile Enteric. But do the recorded rates for bowel diseases in infancy bear out this assumption ? Are the death-rates materially lower under this head, and if so how much must be credited to improved methods of treatment, without affecting the extent of the morbidity ? And then, again, the question still remains as to whether the specific diarrhœa and dysentery may not avail to protect from a subsequent attack of true Enteric Fever, and thus account, to some extent, for the peculiar age-incidence of this infection.

On this question a few remarks are called for, but in the present state of our knowledge these must necessarily be based for the most part on the epidemiological data available. In the first place, we may recall a statement made in their Report by the Commissioners who investigated the origin and spread of Typhoid Fever in the U. S. military camps during the Spanish war of 1898. These officers assert that they began their enquiry in the full and unanimous belief "that acute diseases of the gastro-intestinal tract render the individual more susceptible to subsequent infection by Typhoid Fever." Their conclusions, based upon the investigation of the complete medical history of 12,484 men, are very striking and are summarized briefly, in their own words, as follows :—"Of 4,972 men who had had some preceding intestinal disorder (diarrhœa, enteritis, intestinal catarrh, gastric fever) of a more or less

* Evidence of the presence of the *b. dysenteriæ* in the summer diarrhœa of children is now well established by the researches of American observers.

temporary nature, 407 subsequently contracted Enteric Fever, or 8·18 *per cent.* Of the 7,512 who had had no preceding intestinal disorder, no less than 2,356 suffered from Enteric Fever, a percentage of 31·36. The facts may be stated in another way: among 2,763 cases of Typhoid Fever, 2,356 were not preceded by any intestinal disorder; the percentage of cases of Typhoid which were not preceded by any intestinal disorder was therefore 85·27." The conclusion naturally drawn by the Commissioners is "that many of these supposed diarrhœas were really manifestations of infection by the *b. typhosus*, since we cannot otherwise account for the protective influence here so strikingly manifested." A more general conspectus of the evidence from all sides may, however, serve to modify this "specific" and purely bacteriological conclusion, *e.g.*, when we regard the facts of the incidence on race, in locality and in time, as well as on bodies of men exposed under the same conditions.

As to race, dysentery is the peculiar scourge of all primitive civilizations and the peoples living under them appear to have a decided, if a relative, measure of immunity to Enteric Fever. To examples already given we may add the instances of the White and Coloured troops in the American army, the latter being more than twice as liable as the former to attacks of dysentery, and the same result is on record for the European and native troops of the British army in the West Indies; but as regards Enteric Fever the relative positions are reversed. (Munson, "*Military Hygiene.*") The Kaffirs of South Africa afford another example and, not to extend the references to well-established facts, we may merely point to similar instances furnished by the native Egyptians and the Japanese, the case mortality from Dysentery among the latter being given as 25 *per cent.* (Bruce, in Report of South African Commission on Enteric Fever and its relation to Dysentery.) In the Polynesian Islands, dysentery is the chief scourge of the natives, but Enteric Fever is, or was formerly, unknown until imported by a European. The same is reported of British New Guinea and the West Coast of Africa (Sir W. Macgregor, M.D., *B. M. J.*, October 6th, 1900). Finally, the records show that during the decade 1891-1900, the European troops in India were admitted to hospital for dysentery at the rate of 29·6 *per mille*, and died at the rate of 0·87, whereas among the native prisoners, representing the general population, the ratios were 99·6 and 6·81, respectively. During the same period the corresponding rates, as recorded for Enteric Fever, were, for Europeans 24·2 and 6·46, and for native prisoners 0·25 and 0·11, *i.e.*, the latter were nearly 100 times less liable to a recognized attack and 60 times less liable to die from the disease, than the former. Further, it may be noted that under present conditions (1900–1904) 36 *per cent* of the total mortality of the European troops is ascribed to "fevers" (Intermittent, Remittent, Simple Continued and Enteric) and only 5·5 *per cent* to dysentery, whereas, for the native prisoners, the percentages are, respectively, 7·2 and 20.

As to the relative local distribution, we find dysentery as an endemic disease, more and more prevalent as we pass from the extreme North and South respectively to the Equator, and from cold, dry, continental, inland and upland regions to the hot, moist coast and deltaic areas ; whereas, as a general rule, the reverse is the case for Enteric Fever. When we compare the incidence of the two diseases on the different geographical groups (India), see Chapter IV., we find an almost complete contrast, there being only one aberrant instance, *viz.*, that of the Western Coast (X) where the average strength is small (1,500) and where, though both dysentery and Enteric Fever take a low place, the case mortality of the former comes second on the list. The incidence on the European troops according to the admission-rates (1891-1900) is in the following order from greatest to least : by Groups :*

DYSENTERY	IV,	I,	XI,	II,	V,	IX,	XII*b*,	VI,	VIII,	VII,	XII*a*,	X.
ENTERIC FEVER	XII*a*,	VIII,	V,	VI,	IX,	VII,	XI,	XII*b*,	IV,	I,	X,	II.

There was an old tradition, now exploded, that an antagonism existed between the virus of Malaria and that of Enteric Fever (Boudin's theory), but the facts on which it was based may be explicable on the view that the local distribution of Malarial Fevers and dysentery coincide closely, and that the latter does afford some protection against Enteric Fever.

As regards the local incidence of Enteric on the natives it will be seen later that there is evidence of somewhat greater liability (while this is everywhere small) in those areas where dysentery is least prevalent, when the altogether special case of the Gurkhas is excluded.

* "Dysentery" is not a specific entity and is subject to personal idiosyncrasies of diagnosis in the Returns, otherwise the contrast here exhibited would, doubtless, be still more striking.

Dr. Waldo in his Milroy Lectures (1900) has some interesting remarks on this subject in connexion with the local distribution of diarrhœa and Enteric in England and Wales, in 1881-1890. He shows that, during this period, there were 5 counties which showed prevalence (*i.e.*, had rates above the mean) of both diseases; 3 counties with prevalence of Enteric and not of diarrhœa; and 4 counties with prevalence of diarrhœa but not of Enteric Fever. He says:

> "It seems reasonable to say that although the conditions which favour Enteric and those which favour diarrhœa may, and often do, co-exist and although the sets of conditions may have something in common, still there are essential differences between them. Given a district in which Enteric Fever is persistent and prevalent, it would be unsafe to infer that it would suffer severely from diarrhœa also. And the converse holds good,"

as shown by instances cited. He sounds a note of warning as to the effect of preventive measures on local incidence.

> "The spread of Enteric has been traced to the distribution of a specific bacillus, usually in water or milk, and any outbreak leads to immediate investigation of the source of infection; cases are notified, patients are isolated and disinfection is systematically employed. There are thus active forces constantly engaged in diminishing Typhoid Fever, and that alone would vitiate any comparison with diarrhœa."

These considerations do not apply to the general civil population in India, and though they vitiate a demonstration of antagonism between the two diseases in England, it may be said that the facts as a whole lend considerable support to a provisional conclusion in favour of the view set forth here. Where anomalies to the rule of antagonism are found, it must always be remembered that the agents of both diseases have strong biological affinities and that their propagation and spread are favoured by similar conditions; we should, therefore, expect, not antagonism and alternative distribution, but general coincidence.

In respect of the time relationship we may note that with the decline of dysentery and diarrhœa, Enteric Fever has increased generally, both in the West and in the East; compare the charts showing the course of these different diseases (Chapter II.). It is true that in certain years of the record Enteric Fever and bowel diseases are alike excessively prevalent, but that is because like conditions favour the propagation of both classes among a susceptible population exposed, but it will generally be found that a specially wet season which promotes the prevalence of ordinary intestinal disorders is followed by a diminished amount of Enteric, which may be due to the depurating effect of the rainfall on the soil (Chapter VII.) or to a measure of protection conferred by the antecedent greater prevalence of bowel diseases. There is certainly evidence of dysentery and Enteric running a concurrent course in the same individual, and of the one disease following closely on the other, but such incidents are comparatively very rare when the enormous prevalence of both is considered, *e.g.*, in India and under the conditions of field service; it is easy to understand why this should be so,—the difficulty is rather to account for its rarity without impugning the assumption of an antagonism, which the rarity of the occurrence indeed tends to support. On the other hand, if diarrhœa and dysentery tend to predispose to Enteric infection we should expect to find the latter most prevalent when the former are most rife, especially under the conditions of the rainfall and water-sources that prevail in this country, the wells and rivers exhibiting the most delicate sensitiveness to soil conditions under the influence of precipitation. But this is not the case, but quite the reverse, and it will be remembered that the case mortality from Enteric during the chief period of bowel diseases does not indicate any notable diagnostic error in returns. Where Enteric Fever is at its worst, as in the typical dry continental area, the seasonal incidence of bowel diseases and of Enteric is most distinctly contrasted; where this contrast is not so marked, the seasonal incidence of both is more equally distributed between the hot, dry and the wet periods.

It would be desirable to obtain more direct evidence from a study of the medical history sheets of the men who have, or who have not, contracted Enteric Fever, in order to see what part dysentery has played in their experiences. The data for this analysis are unfortunately not available, but some indication in this connexion may be derived from the statistics of corps units, given for five years only (1895-99) in the Annual Reports of the Sanitary Commissioner (India). In the first place, it has been shown that the Cavalry arm is always subject, as a whole, to a much heavier incidence of Enteric Fever than the Infantry, and we may compare the mortality rates returned for the two diseases from both arms. (See next page.)

Taking, next, for comparison the six Infantry regiments from which the highest Enteric rates were reported and the six Infantry corps in which dysentery claimed most victims, *Enteric Fever and Dysentery. Mortality* per mille *of Strength, on Cavalry and Infantry*, 1895–99.

European Troops in India.	1895.		1896.		1897.		1898.		1899.	
	Enteric.	Dys.	Enteric.	Dys.	Enteric.	Dys.	Enteric	Dys.	Enteric.	Dys.
Cavalry ...	7·35	·37	6·29	·19	15·42	·98	11·95	1·03	11·99	·22
Infantry	5 85	·80	6·83	·77	8·62	1·26	10·85	·80	4·53	·67

and combining the results to obtain means for the same quinquennium, we get the following results:—

	Enteric Fever.	Dysentery.
Corps with highest Enteric Mortality (Agg. strength 24,426)	21·78	0·93
Corps with highest Dysentery Mortality (Agg. strength 24,798)	6·26	3·73

It is not contended that this affords more than a general indication of some mutual exclusiveness on the part of the two pathological processes, and a more valid comparison will be found in the case of the Gurkhas and the other native troops of Indian race who are cantoned in the same stations. It will be seen subsequently that the Gurkhas (natives of Nepal) are about six times more liable to Enteric Fever than the other native (Indian) troops, but, if we compare the incidence of dysentery on the two classes when stationed in the same cantonments, we find that the mean rates *per mille* for the last five years (1900-04) are, for Gurkhas, admissions 21·3, and deaths ·10, while for the natives of India they are 48·9 and ·33, respectively; *i.e.*, the morbidity from dysentery among the Gurkhas, who are exceptionally liable to Enteric Fever, is considerably less than half, and their mortality less than one-third, of that of their Indian comrades. An almost identical result is obtained when the rates for the Gurkhas as a body are compared with those recorded for the rest of the native army dispersed all over India.

If no single one of the foregoing considerations be held to carry much weight, it will be allowed that their collective force is undeniable, when the biological and epidemiological affinities of the causative agents and of their pathogenic results are fairly and fully regarded.

Having thus seen, as we believe, that there are demonstrable or, at least, highly probable factors operating to promote a relative immunity to the attack of Enteric infection in the case of natives of tropical and sub-tropical regions, we have still to enquire if, after all, the simplest explanation does not lie in one or other of the current views which invokes either the protection afforded by the recovery from the disease in infancy; or, starting from the connexion of Enteric Fever with an insanitary environment, assumes the perennial and ubiquitous presence of the specific virus, with constant imbibition of the virus, and the consequent evolution of the power of resistance on the part of the individual. Either explanation would have the merits of simplicity and of consonance with some of the salient epidemiological facts. But, unfortunately, we can at present only meet *à priori* arguments with others of a like invidious nature ; there is little or no definite and strictly scientific evidence to appeal to.

No better statement of the case for the first of these hypotheses has been made than that by Surgeon-Major Chester, A.M.S., in the *Lancet* of August 31st, 1895, the main point of his contention being that when and where infantile bowel diseases were, and are, most rife, then and there Enteric Fever was, or is, not recognized among adults. He thus accounts for the rise of Enteric Fever in Europe after the inauguration of the sanitary era and for the excessive susceptibility of newcomers to a locality over that of the natives. This view assumes that in so far as there has been a decline in the prevalence of infantile bowel diseases, it is to be referred chiefly to the disappearance of Enteric Fever at the earliest ages, and further that the susceptible visitors always come from a more sanitary environment in regard to the prevalence of these infantile disorders.

There is certainly more to be said for the latter assumption than for the former which, however, is the main question. As to this it can only be replied that there is no evidence of a decrease of infantile bowel diseases ; the mortality therefrom has not shared in the decline that has marked the incidence of certain other "zymotics" in England, and Dr. Newsholme, than whom there is no better authority, showed in 1899 (Address to the Association of M. O. H.) that, taking diarrhœa and enteritis together, there has been no decrease, a fairly steady average of mortality from these causes having been maintained since 1847. No argument can, therefore, be based on assumed alterations in the diarrhœa rate; while the fact that Enteric Fever has declined in England and Wales during recent years may be attributed to the special measures directed against this infection. This of itself would leave larger numbers of susceptible subjects open to attack when exposed to the infection, but the phenomenon cannot, on the evidence, be attributed to the absence of universal protection in infancy. It may be noted that infantile diarrhœa is an affection to which the lower classes are peculiarly liable, which may serve to explain the *comparative* immunity of these classes from Enteric Fever as compared with the established liability of the well-to-do, which tends further support to the view of a protective influence derived from attacks of diarrhœa and dysentery.

There still remains the question of the true etiological nature of these bowel diseases, and, taking the most authoritative European opinion, we are probably on safe ground in doubting its specific Enteric origin (*see* Curschmann in Nothnagel's *Encyclopœdia*). As regards the East, there is a paucity of scientific evidence, but this, so far as it goes, is not in favour of the assumption of a monopoly of Enteric infection by native infants. In China there has been a general consensus of medical opinion to the effect that while Enteric Fever undoubtedly exists, it is relatively uncommon among the natives, and the view has been propounded that protection is gained by attack in infancy. On this point Dr. Hunter, Government Bacteriologist, Hongkong, makes the following interesting and valuable observations in his Report for 1904. For good reasons given, he rejects the evidence derived from hospital practice and discusses the results "of the enormous number of *post-mortem* examinations held at the Public Mortuary;" of these he says:—

"That the experience to be gained of the frequency and occurrence of diseases of infants and children is large, goes without saying, when one considers the average number of autopsies held at the Public Mortuary annually. During 1904, out of a total of 1,551 *post-mortem* examinations, no fewer than 498 autopsies were held on infants under one year. Further, over 50 per cent of the total number of examinations are conducted on children under five years of age. This high percentage of children examined has been maintained since I assumed charge of the Public Mortuary about three years ago. During the past three years, no fewer than 6,693 *post-mortem* examinations have been made, and about 60 per cent of these have been performed on children under the age of five years.

During the years 1902 and 1903, few cases of Enteric Fever were examined at the Public Mortuary. Seven cases were met with during 1902, and one during 1903. The following tabular statement is interesting as regards the age incidence :—

In 1902 :—

0— 1 year	No	cases.
1— 5 years	4	,,
5—10 years	1	,,
10—20 years	0	,,
20—40 years	2	,,

in 1903, one case in an infant under one year.

At first sight, the table given for 1902 creates an impression in one's mind that even in the presence of so few cases, the disease is common during childhood, and more common amongst Chinese children than amongst Europeans of the same age. However, if this table is to be interpreted correctly, one must bear in mind the disturbing factors which arise in estimating the incidence of the disease amongst the Chinese.

First of all, the number of children brought for *post-mortem* examination greatly exceeds that of adults. Again, older children and adults promptly leave their dwellings in Hongkong and proceed "to the country" when premonitory symptoms of any disease appear. The same argument applies to the cases of Typhoid Fever examined during 1904. During the past year, quite an appreciable number of cases were brought for *post-mortem* examination, and proved to be of considerable scientific interest, for no fewer than 47 cases of the disease were met with in the Public Mortuary. Each case was pathologically examined with care, and in a few cases the *bacillus typhosus* was isolated, thus rendering the diagnosis beyond dispute.

The following are the figures for 1904 :—

	cases.
0— 1 year	16
1— 5 years	14
5—10 years	2
10—20 years	1
20—40 years	14
Total	47

As will be seen, my experience of the disease in Hongkong is not a large one, but, owing to the fact that all the cases were diagnosed by *post-mortem* examination, the results of the past year are of value in regard to the geographical distribution and age incidence of this disease in the Far East. At first sight, the figures given for 1904 would appear to support the dictum that in China Typhoid Fever is a disease of infants and children. The figures are largest amongst children under five years of age. However, it must be noted that during 1904—and this is the only year from which I can deduce any conclusion—the incidence of the disease reaches double figures between the ages of 20 and 40 years. The difference in the number of years of exposure to the infection during these two periods is considerable, but, from what has already been said earlier in this paper, this large incidence of the disease in children under five years of age, by no means proves the frequency of infantile typhoid. In support of this contention, I bring forward the following:—

(1.) That 60 per cent of the total number of *post-mortem* examinations held at the Public Mortuary are on children under five years of age. If this point be taken into consideration, it is evident that more cases of Typhoid Fever will appear amongst children, and possibly lead to error in estimating the age incidence of the disease.

(2.) That during 1904 about 30 per cent of the total number of cases of Typhoid Fever occurred in adults. This is important when one remembers that only 40 per cent of the total number of *post-mortem* examinations are held on adults.

(3.) That infants and children found sick or dying in Hongkong are taken to one of the convents, or "dumped." They are rarely taken "into the country."

(4.) Adults, finding insidious disease creeping on them, return post haste to their homes in China.

(5.) The belief in Oriental immunity to Typhoid during adult life is not supported by my results.

(6.) In conclusion, I am inclined to the opinion that the Chinese suffer from Enteric Fever as frequently during adult as during infantile life, and were the customs of the people and the conditions of life regulated in a manner similar to those of the Occident, the incidence of this disease would differ but little from that found in Western countries. In the latter, Typhoid Fever is also found in infants and children, but its incidence is smothered up by large figures which mark the occurrence of the disease in adults.

In regard to the general statement in the last paragraph, it will be seen that a total of 55 cases were met with in the three years, among 6,693 autopsies, about 0·8 *per cent* of the whole. In England and Wales, where the combined mortality is probably only about half of that of the Chinese, Enteric Fever accounts for approximately 1·2 *per cent* of the total. But it would be idle to endeavour to make any valid comparison on the data furnished for obvious reasons ; the age distribution of the population is not proportionately represented in the autopsies, and this may well be the case also as regards the mortality ; the results in 1904, when there were 47 cases out of a total of 55 may represent an excessive and temporary epidemic prevalence of the disease. Dr. Hunter concludes with an account of the bacteriology of the disease as met with in infants, in which the *post-mortem* appearances were typical. "Several" cases were examined, but in two, bacilli were isolated which failed to correspond exactly with the classical *b. typhosus*, and he is inclined to think that in one case the organism was closely allied to the para-typhoid group, and in the other the most notable characteristics were those of *b. coli*.

Turning next to Egypt, we find Sandwith, whose right to speak on this subject will scarcely be questioned, referring to—

> "the erroneous theory that most Egyptians have suffered from Enteric Fever as children, thus procuring an acquired immunity among adults." He adds: "I think I may dispose of this theory quite shortly by stating that I have performed, or assisted at, the *post-mortem* examinations made upon several hundred children under the age of five years, most of them being compulsorily brought to hospital after death, because they belonged to the Foundling Department of the Egyptian Government. These children were formerly farmed out to the poorest women in Cairo and Alexandria, who lived in insanitary huts, many of which contained stinking latrines. The unfortunate children died of diarrhœa, broncho-pneumonia and various forms of septicæmia, but never in one single case have we ever found pathological evidence of Enteric Fever, while those cases which I have watched during life, to elucidate this very question, have never displayed clinical symptoms of this disease, nor answered to the serum test."
> ("*Practitioner*," January 1904.)

Evidence of a similar character is unfortunately not forthcoming in India; autopsies on infants and children are performed by every Civil Medical Officer in the course of his medico-legal duties, but examinations are, as a rule, confined to the determination of the cause of death for what correspond to Coroner's purposes in England, and no combined nor continuous record is available. Ordinary cases of fatal illness in children are very rarely, if ever submitted to autopsy. In the United Provinces of Agra and Oudh (population nearly 50 millions), the causes of death in 11,321 cases occurring among the general native community in 1900 were "verified," *i.e.*, certified after enquiry, by civil practitioners, and of this number, 19 were ascribed to Enteric Fever, but it does not appear that any of the 19 occurred among the 4,794 children under 16 years of age whose deaths were included in the total; but it is not intended to lay stress on these results which are obviously open to fallacy. The writer has been favoured with reports from a few of the lady practitioners in charge of some of the Dufferin Fund Hospitals, which are also based on clinical experience, and which, while they do not support the view of the prevalence of the disease among children, are necessarily limited in scope and are not conclusive from a scientific point of view. Dr. Yerbury, of the Lady Lyall Hospital, Agra, furnishes a statement which shows that, during the seven years ending 1904, 18 cases of Enteric Fever came under treatment out of a total number, admitted for all causes, of 7,531, of which 726 were classed as "Fevers." The ages of the Enteric cases were as follows in years: 1, 1½, 2, 3, 3½, 5, 6 (three cases), 7, 8, 9, 12, 13 (two cases), 15 (two cases) and

18 years. Eleven of the total were Native Christians from an orphanage; three were Eurasians living in cantonments; three Hindus, and one Muhammadan, who came from the native city. The diagnosis was based on the clinical evidence, no *post-mortems* were made, and in two cases subjected to the serum test, the result was negative. The excessive proportion of Native Christians and Eurasians in the list must be discounted by the fact that these classes are far more likely to resort to hospital than Hindus and Muhammadans, the number of whom in the population vastly exceeds that of the former. Dr. Dorothy Pratt of Srinagar, Kashmir, "considers Enteric Fever fairly frequent among the women and children," and that "children are much more susceptible than adults;" but she ascribes the latter impression to the fact that children are often brought to hospital and left there, "while the adults would never become inmates of hospitals." The hospital registers show that the purely medical cases form about 17 *per cent* of the total admitted to the wards and of this proportion, *i.e.*, of the total medical cases, 2·5 *per cent* were Enteric Fever in 1904. None of the cases were verified by autopsy or by the serum test. The Medical Superintendent of The Duchess of Teck Hospital, Patna, Bengal, says, that although she has held charge of the institution for nine years and sees about 6,000 patients annually, she has met with "very few cases of Enteric Fever," and considers that natives enjoy a relative immunity from constant "imbibition of the poison." Dr. Hope and Mrs. Hope of Pabna, Bengal, who have practised among a rural population for seven years, believe that the disease is relatively "exceedingly" rare among the natives, and have not seen fifteen cases during that period in which they could confidently make a positive diagnosis; but Widal's test has not been employed in any case. Previously, in Australia, their experience of Enteric Fever was abundant. The records of the Ishwari Memorial Hospital, Benares, for the last twelve years, show only six cases admitted for the disease of whom four were Eurasians and two Hindus.

It will be seen that no definite conclusion can be drawn from these inadequate data, but it has been deemed advisable to put on record the impressions of qualified practitioners who come into closest contact with native children, and it should be added that there is a general consensus to the effect that the disease does not occur in epidemic form even in the crowded slums of the large cities. The registration of mortality and of its causes is conducted by a very primitive and illiterate agency; the vast majority of the people die without medical attendance of any kind and a considerable proportion of the deaths of infants escape the record. Enteric Fever is not given a separate place in the returns, and when it occurs in a fatal form it is probably included under the heterogeneous heading of "Fevers," provided the death is registered. Nothing would be gained, therefore, by submitting these returns to analysis; it may merely be said that the infantile mortality rate is probably, all round, in normal years nearly double that recorded for the United Kingdom (say 280, against 150) but varying enormously in different areas, and in different years in the same area; and beyond this that bowel complaints and "fevers" are undoubtedly responsible in overwhelming measure for these results. But this, of course, is precisely what might be expected in the circumstances of a poor and ignorant and primitive people in a tropical region without adequate sanitary safeguards or medical aid, and whose marriage and other customs necessarily involve a great sacrifice of infantile life. We have not to go beyond the United Kingdom, to find examples which exhibit conditions very similar to those prevailing in India; *e.g.*, in Dundee, where the jute industry involves female labour and neglect of the children, the infantile mortality being enormous. The infantile mortality of different peoples and races may, however, be said, generally, to increase in a certain direct proportion as we leave Northern latitudes and travel East and South towards the equator; the standard of comfort and hygiene at the same time falling and the birth-rate rising. The question is whether this excessive infantile mortality has any definite causal connexion with a relative immunity to Enteric Fever in the regions, and this can only be decided by exact research directed to the point at issue. At present there is no evidence in favour of the universal or excessive prevalence of the disease among infants and children in the tropics and subtropics, but, on the contrary, many of the considerations and facts adduced appear to conflict with this assumption. Unless, indeed, it be universal, it is difficult to account for adult immunity, except on one or other of the hypotheses stated, when regard is paid to the conditions of life, the close aggregation of the family bond, commensality, etc., under which infection if present, must be propagated and spread. It may be pointed out that in Russia, where the infantile mortality reaches a point little if anything below that of India under normal conditions of the food supply, the adult population does not exhibit this relative immunity, and the incidence of the disease on the Russian army on field service presents a most marked contrast to that suffered by the native army of India under like conditions. In the Afghan campaign, 1879-80, with an average strength of about 26,000 native troops in the field there were only 26 cases and 10 deaths recorded. In the Frontier campaigns of 1897-98 (Tochi, Malakhand, Tirah, etc.) among an average force of over 10,000 men, only five cases and two deaths were reported. (See Chapter IX.)

Attempts have been made to bring evidence to bear from another side, *viz.*, by the subjection of the blood of healthy native children and adults to the serum test as in the series reported by Surgeon-Major Freyer, A.M.S. (*British Medical Journal*, August 7th, 1897), in which he obtained positive results. But the technique employed by him was open to grave criticism on fundamental points and a more careful repetition of the test in a larger series of cases by Captain Lamb, I.M.S. (*Indian Medical Gazette*, April, 1901), must be held to be entirely conclusive in refutation of Freyer's position; in 36 cases the result of the test was clearly negative. Crombie has reported that the blood of certain Bengali students residing in England has given a positive reaction with *b. typhosus* in spite of the fact that they had never suffered from illness that could be ascribed to Enteric infection, so that while these results might be taken to support those obtained by Freyer, the interpretation of the cause of the phenomenon is totally opposed to his. On a judicious survey of this evidence we must prefer the demonstration of Lamb, which is in conformity with that of Vincent in the case of the Arabs already mentioned, which would appear to establish the fact that the reaction is not associated with immunity but with changes induced in the tissues by present or recent infection; *i.e.*, immunity can and does often exist and yet the blood has no power of specific agglutination, a fact long established in connexion with the negative action of the blood of certain animals on bacteria pathogenic to other animals, but to which they themselves are immune.

There is, finally, one other consideration which has, indeed, only a relative and circumstantial value as evidence, and that is that if native children are invariably subject to Enteric Fever, most Indian "compounds" should be hotbeds of infection, as, shared among the dozen or so of native servants living in huts in close proximity to the European Civilian's house, there is invariably a goodly proportion of children. Intercommunication is constant and the food and waters-supplies of the house are specially and constantly exposed to risk. And yet Enteric Fever is a comparatively rare event among Civilians and their families when a comparison is made with the incidence on the troops. The present writer was for over 7 years in medical charge of a large civil station in the United Provinces equidistant, and not far, from both Meerut and Agra, where the disease has ever been at its worst among the troops; but with about 15 European families under his care he never had a case of Enteric Fever, nor was there an authentic case on record in the annals of the place, save in the persons of two tourists who were infected on arrival and were stricken on their journey. The experience in regard to cholera and dysentery was, unfortunately, far less happy.

If we look at the experience of Agra itself in recent years, as to which I have been favoured with a note by the late Civil Surgeon, Colonel Lukis, I.M.S., an officer of the very highest professional attainments and of great experience, the record of Enteric attacks among the Civil European population is as follows :—

1. 1894. One Lady Missionary.
2. } 1896. Do. Also a young officer of the
3. } Indian Civil Service, who was a dining member of a Regimental Mess.
4. 1898. A case imported from the Railway community at Tundla, about 4 miles distant, and treated in hospital.
5. 1899. A Missionary.
6, 7 and 8. 1903. Three tourists who arrived in Agra with the disease.

It should be noted that cases 1, 2 and 4 (Missionaries) were believed to have acquired the disease at a place five miles away from the station. Meanwhile, it should be remembered that the incidence of Enteric Fever on the European garrison in the adjacent Cantonment was equal to a rate of 46·3 per 1,000 of the strength in 1891—1900; it was never lower than 15·5 and rose as high as 166·4 in one year, 1897. Now the Civil European population of Agra district is given in the Census of 1901 as numbering 2,761, of which 1,397 were under the age of 30, and for which there is a record of only 4 indigenous cases during 10 years. Colonel Lukis adds that included in his various charges were three Schools and an Orphanage, as well as some local factories, and that amongst the European and Eurasian children in these institutions Enteric Fever is practically unknown. "If I get a case of Enteric that has been contracted locally it is almost certain to have been contracted either in Cantonments or in Sikandra"; "there is very little Enteric Fever either amongst the civil European or Eurasian population or amongst the natives in the City". It is interesting to note in connexion with the view of the etiology of the disease among the European troops which has been adopted in this Essay, that this acute observer remarks: "personally I am very strongly of opinion that the cause of the Enteric Fever amongst the soldiers here is to be sought for *within* Cantonments, and not in the City nor in the water-supply." And this is said of one of the largest Cantonments in India which stands second on the list of Enteric prevalence, and which is situated in close proximity to one of the largest native communities in the Empire.

One more instance will suffice, and we may take that of Meerut where the European population is said to be about 100 with an equal number of Eurasians, *i.e.*, coming under the medical care of the Civil Surgeon, to whom I am indebted for a list of 10 cases treated during a period of 2½ years, *viz.*, 6 Europeans and 4 Eurasians. This would give an attack rate of about 20 *per mille* per annum which is certainly high, but the total civil population (European and Eurasian) living in the Civil Station and in the city and surroundings is given in the Census of 1901 as 1,967, of whom 815 were under the age of 30. Here again there is a large garrison of European troops and the mean admission-rate for Enteric Fever for the decade 1891—1900 amounted to 34·8 *per mille*, the Cantonment standing eighth (out of 73) on the Enteric list (Plains Stations). The particulars given of the 10 cases among the civil European and Eurasian communities show that the dwellings of 4 of them were practically in the Cantonment, *i.e.*, they were in more or less indirect contact with the troops, and three of these got their milk-supply from the Cantonment bazaar. Four others though living in the Civil lines also obtained their milk from the Cantonment, and whether milk were the vehicle of infection or not, there must have been constant and frequent communication with the Cantonment. The last two cases were imported from other stations at a distance, one coming from a neighbouring Cantonment. An eleventh case, which is noted as occurring outside the period of $2\frac{1}{2}$ years in question, was that of a young officer of the I. C. S. who lived in the Artillery Lines (Cantonment) and took his meals at the Artillery mess. So it will be seen that although attacks have been not infrequent, there is a good and sufficient cause for this in the intimate connexion established with abundant sources of infection in Cantonments, and it is quite unnecessary and beside the mark to assume the agency of native children.

If we turn to the records of the Indian Civil Service, we find that 8 officers have died of Enteric Fever during the five years ending with 1905. The strength on the active list is 1,255, but 20 *per cent* of this total may be reckoned as absent from India on leave, and only about 33 *per cent* come within the age-period, 24—29 years, which is also that of the first 6 years of service. Seven of the eight fatalities occurred within this period, which yields a death-rate closely approximating to that of the European troops at the same age, but in the case of the latter the mortality occurs among a body from which the most susceptible subjects have been eliminated by attacks. The contrast is more definitely shown when the results for the same service period are compared in each class, and then the death-rate of the soldier is found, under ordinary conditions, to be nearly twice that of the Civilian Officer. It is to be expected that the young Civilian will show an excessive liability corresponding to that exhibited by the military officer, due probably to the social class from which both are drawn, and as regards the sources of infection, it must be noted that Civilians, on first arrival, are frequently guests at regimental messes and may even share regimental residential quarters of which instances have been given. The record shows that five of the eight deaths occurred within the first year of service, and seven in our "endemic" area, which goes to confirm the evidence, on which stress has been laid, as to the special danger of first exposure to the environment, and which indicates to some extent the probable sources of infection.

To conclude this long and, it is feared tiresome, dissertation, we may reaffirm one or two salient considerations in regard to immunity acquired by constant ingestion of the virus. In the first place, the question of the omnipresence of the true *b. typhosus* remains to be solved. Apart from this it is quite certain that under the conditions of the almost total neglect of personal and public hygiene and of the customs of the people, the high infantile mortality prevailing among the natives of

India must ensure the early elimination of a very large proportion of those individuals whose powers of resistance against the commoner zymotic bowel and filth diseases are low. It is impossible for any one to escape infection so widespread is it, and so manifold the opportunities of its access. All susceptible individuals must be attacked, and all who are non-resistant must die, and the latter event, when it occurs before the age of procreation, must prevent the transmission to offspring of the inherent susceptibility and lack of resistance.

In this way, a racial immunity is evolved which is, however, strictly relative both in nature and extent; it operates only under the ordinary conditions of the life of the host and of the character and amount of the infective agent present. A race cannot secure absolute immunity to a disease like dysentery or specific diarrhœa, but only up to the point of more or less successful resistance to its lethal effects, *i.e.*, to the power of recovery under ordinary conditions, and notably those of a sufficient and suitable food-supply; for the evolution of the power of resistance will cease with the absence of elimination to any marked degree. But we see how untoward conditions of life—privation, famine, excessive prevalence of Malaria, of deprivation of liberty and of aggregation—all work together to lower resistance and to promote morbidity and mortality from these causes, as shown in the excessive rates returned in years when famine and Malaria in excess prevail, and in the greater incidence of bowel diseases on the prisoners as compared with the native troops. Innate immunity is moreover never absolute, but wherever a disease is very prevalent and fatal, we find that under ordinary circumstances, the number of individuals who are immune and of those susceptible to attack but who recover, tends to increase, while the number of those who succumb decreases. This is the general rule, but the three categories are not strictly demarcated, and an alteration of the conditions of life, involving the lowering of resistance, will tend to bring a larger proportion into the third category, with subsequent exaltation of the racial immunity (first category) on the return of normal conditions.

Beyond this the individuals of a race so exposed acquire a measure of immunity which, however, is not transmissible to the offspring; it is strictly personal. This is a physiological process of "acclimatization" due to the reaction of the tissues to the causative agents of disease, and in the case of intestinal "zymotics," this immunity is both local and general, the intestinal tissues and the systemic leucocytes becoming habituated and adapted to the bacteria and their products from constant experience thereof. In respect to the relative operation of these two forms of immunity, dysentery and the commoner allied bowel diseases stand between Tuberculosis and Enteric Fever.

Further, experience shows that a given disease, once prevalent among a people, may almost entirely disappear under altered conditions of civilization,—diet and improved sanitation;—the host is fortified against attack and the specific agent is removed. This is seen in the case of dysentery in the United Kingdom, but nevertheless if the English return to primitive conditions of life (as in Camps) or to places where the disease is endemic, they are again subject to its attacks in proportion to their exposure thereto. This would appear to indicate that the Enteric bacillus is not generally present in the particular environment of the natives of India or Egypt, &c.; for all the other conditions necessary to its propagation and spread are forthcoming to an extent elsewhere unparalleled. Sporadic and relatively infrequent cases are undeniable, and these occur for the most part under conditions approximating to those under which Europeans live; but epidemic outbreaks in the sense of European experience are unknown. Moreover, the cases hitherto scientifically authenticated have occurred for the most part among those whose antecedents, nurture and surroundings would be likely to secure them to some extent against the attack of other specific bowel diseases.

So far for the operation of the commoner intestinal "filth" zymotics, and the question remains as to the effect of these in establishing resistance to the *b. typhosus*, which, whether present or absent in the Native environment, does not produce the effects which are experienced among Europeans. This is one of the main questions to the solution of which scientific research must be directed. We have, to start with, the biological affinities of the micro-organic agents, members of a group that probably own a common origin, but diverging in certain respects in adaptation to their life-conditions and to their parasitic opportunities. We have, further, the epidemiological evidence in support of the view of a considerable measure of mutual exclusiveness (of alternative incidence) under conditions which largely favour both.

One fact is however well established, *viz.*, that when different species, adapted for different processes, follow one another in sequence (metabiosis) the end members of the series, those best adapted to the beginning and those best adapted to the end of the process, are often in antagonism. This is notoriously the case with organisms concerned in putrefactive and fermentative actions, and antagonism is frequently seen between pathogenic and putrefactive bacteria.

There is at least justification for the bare suggestion that the vital reaction in response to the stimulus of the commoner excremental filth parasites may well prove effectual against the attack of their more highly evolved ally and relative—the *b. typhosus*,—in relation to which the former may act the part of attenuated and less toxic forms of the same ultimate species. It would be going far beyond our present justification to suggest that they represent the "T. C." in its relation to the "T. V." of the *b. tuberculosis* as differentiated by Behring in his recent pronouncement to the Congress at Paris, but this broad analogy may serve to elucidate the view here faintly adumbrated. Beyond this, it has always to be remembered that the essential property of immunity depends ultimately on the functions of the tissue cells and on the liberation from them of forms of energy in response to stimuli that need not necessarily be "specific" in the purely bacteriological or homœpathic sense. Sometimes the specific isopathic stimulus is best adapted for thus rendering active the tissue-proteid, but sometimes a heterogeneous and specifically dissimilar, or even an entirely foreign stimulus is sufficient, and may even exceed the former in the reaction called forth (Hueppe).

Although some criticism has been offered in regard to the operation of certain of the factors which are held to explain the relative immunity displayed by the natives of India, our last word must be that, in all probability, all the factors, as classified, take an effective, if varying, share in the results we are about to summarize. And lastly, whatever view be adopted as to the extent and causes of a relative immunity, we may not overlook the possibility of natives acting as "*bacillenträger*" in the dissemination of infection, on the analogy of the possible importation of yellow fever and malaria into Central America and the West Indies by negro slaves.

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Summary of the Etiological factors and their relation to Immunity. Supplement to Chapter III.—At this stage, it will be well to recapitulate some of the main considerations that should be borne in mind in endeavouring to appreciate the bearing of the evidence at our disposal, and in all further attempts to arrive at a solution of the etiological problem. We shall here take a broad view of the biological factors in operation, which may serve to co-ordinate the illustrative data set forth in the discussion, as regards Europeans and natives alike.

(1) Once more we must ask the reader to accept the definition of the disease process which is set forth in Chapter III. (page 57), and to realize the paramount importance of the "quality" of the tissues of the host (the "soil") in regard both to the necessary predisposition and to the evolution of the "specific" pathogenic energy of the germ stimulus (parasite). Given the "predisposition," or a depression of the physiological resistance, normal physiological stimuli may become disease stimuli; or, the organization and resistance remaining the same, the stimulus may become more intense (virulent) and set up the reaction of disease. Thus disease depends qualitatively* upon the kind of organ or tissue concerned and upon its internal adjustments (Virchow). The facts that the majority of the individuals of any one species are ordinarily immune to any one specific disease; that certain animals are ordinarily immune to certain diseases which are fatal to varieties of the same species, and that the former can be rendered susceptible by altering and depressing the natural resistance of their tissues (local or general), are only to be interpreted from this standpoint.

(2) From this we pass to the origin and evolution of the "specific" parasite (see Chapter III., pp. 56 *et seq.*, 110 *et seq.*). We abjure the doctrine of "special creation" of different species, and we postulate derivation from a common ancestral saprophytic form, the chief if not the only, factor in determining "specificity" being the nature of the "soil," *i.e.*, the pabulum available; we contend, therefore, for *nutritional varieties* in place of specific genera, as a fundamental consideration for practical purposes with which the botanist or zoologist has no concern. It is to be remembered that amongst pathogenic organisms in general, there is as little constancy of pathological potency as of morphological characters or chemical activity (Kanthack); moreover, pathogenic bacteria

* A *quantitative* distinction may be drawn in regard to the metabolic activities displayed in the splitting up of the albuminoid molecule, by the true parasite and its saprophytic congener (or ancestral form) respectively. The dissociation of the living protoplasm at the temperature of the body is the faculty which characterizes the pathogenic micro-organism, but this power of the infectious agent is one with that of the toxic and of the simply saprophytic bacteria, since these latter are able to produce similar if not identical poisons from dead albumen.

must always be studied in relation to their origin and to their saprophytic (nutritional) relations. Now their origin must be sought in the necessity for the maintenance of the cycle of life, by the decomposition and resolution of all effete matter into forms suitable for plant and animal food. In the processes of putrefaction (in the splitting-up of the albuminous molecule) which form an essential link in the cyclical transmutation of matter, the fundamental phenomena of parasitism are foreshadowed, out of which, by the development of the saprophytes concerned and by their access and adaptation to human hosts, the various advanced stages of parasitism have arisen. Conversely, we know that attenuated cultures of specific parasites afford, when introduced into the body, (vaccines), protection from the effects of their virulent ancestors, while powerless of themselves to produce disease. Non-pathogenic varieties may, and do, also originate spontaneously from the virulent organism, and then they grow more vigorously on artificial media,—a reversion to saprophytism. The correlated processes of infection and of immunity are alike derived from the original function of splitting-up the albuminous molecule. These saprophytes are doubtless of far longer pedigree than man, and what we call their specific pathogenic forms must have evolved with man; specific diseases have therefore borne an important part in the history and evolution of man, and the different stages of his civilization have afforded varying facilities for the evolution of different parasites, either obligatory or conditional, according to the conditions; *e.g.*, aggregation providing a due succession of hosts, or the reverse.

Starting from the origin and saprophytic functions of bacteria we are thus led to their commensal and, finally, to their parasitic life stages, as adaptations to their nutritional needs, and the results are determined by the nature of the "soil" or pabulum,—fermentation, putrefaction or disease. And in regard to the last, they must always be viewed in their relations to the tissue cells of the host (rather than to the corporate individual), these being unicellular bodies like themselves. Now note that in unicellular organisms, nutrition and the propagation of the species may be considered as one function; the result of the struggle for food is the sole determining factor of their maintenance, and both tissue cell and bacterium are prolific under favourable conditions and subject alike to the laws of heredity and variation. The recent work on the reaction of the organism of one species to the tissue cells of another species, and the production thereby of specific cytolysins, will serve to illustrate the elemental likeness of these unicellular bodies, bacteria and tissue cells, and their inter-relations. And in connexion with their nutritional functions, Ehrlich and Metchnikoff have postulated with great force, that the same physiological provision for the assimilation of food on the part of the tissues (Receptors) operates to determine the results of a bacterial invasion. Much will therefore depend on the haptophore groups of the Receptors possessed by the bacteria and the tissue cells respectively, and this will be determined largely by the nature of the food to which each has been adapted and to their previous experiences in the course of their evolution. The nutritional requirements of each are often antagonistic, but the physiological provision for satisfying these, as would be expected, is similar, and we get the explosion of latent potential energy which leads in the first place to propagation on both sides, just as if by contact the one fecundated the other. In that they are both unicellular organisms, with no distinction between body and germ elements, the transmission of acquired characters, derived from adaptation to the common environment and from their own interaction, is not only to be expected, but must involve the evolution of "specific" properties in both; thence arise different measures of predisposition or resistance on the one hand; the evolution of pathogenic properties, the exaltation of virulence or the reversion to the saprophytic stage on the other hand, through every grade of physiological or pathological reaction. The ectanthropic relations of the bacterium may well prepare it for development upon the anthropic stage; for

(3) In all intestinal infections there is evidently a specially close relation between the pathogenic parasites and the saprophytic agents of putrefaction; the essence of "specificity" lies in the character of the nutrient medium, whether it be available in the tissues of the host (in a state of depressed vitality, or on the way to necrosis) or in dead pabulum within or without the body. We see many of the putrefactive organisms generating out of the food residues, poisons that affect injuriously the human body without direct participation of the bacteria themselves, and such organisms may be in the conditional stage (commensality) on the way to effective parasitism. Access of a putrefactive saprophyte to the intestine provides the conditions of segregation which are requisite for

the development of "specific" characters. In this connexion, we may surely look for different results in vegetarians and in meat-eaters whose dietetic habits involve a call upon the small intestine which should only be made upon the colon. Further, in the former case the diet is spare and practically the same day by day, year in, year out ; for the latter, it is mixed and has a large meat element ; it is never two days alike and generally in excess of physiological needs. Then we recognize the fact that under normal conditions of health there are myriads of filth organisms, and no lack of filth undergoing fermentation and putrefaction, in the intestine ; we also recognize an enhancement of local tissue resistance from "experience" of the prevalent flora, *e.g.*, *b. coli*, whereas when this gains access to one of the closed and ordinarily sterile sacs of the host it sets up pathogenic effects. We may, therefore, infer that when *b. coli* travels from its proper habitat, either within the body of its original host or from one human host to another, there will be danger of an abnormal reaction, especially when the resistance of the fresh tissues invaded is lowered by any cause. At the same time persons who are habitually subject to the ingestion of such filth organisms will offer a greater resistance ; those long subject to better sanitary conditions will be more likely to suffer. Compare the fœtus *in utero* and the suckling with the weaned infant, and the relative propensities to infections in general and to bowel diseases in particular. This local immunity of the tissues is of great importance ; it explains the greater resistance to infection conferred by age, and Escherich, Heubner and Baginsky have shown that *b. coli* exercises an infectious pathogenic action on young children, which it loses for older individuals. It also explains the phenomena of the "*bacillenträger*," the originally peccant organism living as a harmless saprophyte in the intestine, while maintaining its virulence for other susceptible hosts. This local tissue immunity appears to be retained for long periods against those pathogenic germs only which, while in the living state, attack the host spontaneously ; an animal (host) may be very susceptible to infection by experimental inoculation and yet not suffer from epizootics by spontaneous access of the germs, even though these be widespread. This is probably due to local resistance of the tissues of the ordinary channels of spontaneous infection ; such immunity is quite distinct from the systemic serum-immunity (Wassermann and Citron). Finally, we have to take account of the selective affinities of pathogenic parasites for special tissues, and in the case of Enteric, these tissues are precisely those which may be expected to evolve a high measure of resistance from experience of bacterial forms having a close generic relationship. At the same time no tissues are so ready to adapt themselves to the conditions of their life and functions (food, etc.), they being in closest touch with the environment.

(4) In the light of these observations we must keep in view the essential facts of organic evolution; of variation and heredity and the struggle for existence involving adaptation to the environment on the part of both the tissue cells of the host and of the parasite, noting that each forms a most important element in the environment for the other.* That is to say, that each is not only profoundly influenced by the external forces common to both, but that they react upon each other. Just as the host being possessed of a definite organization is compelled to adapt himself continually to changing conditions of life, so also is the microbe under the same obligation. There is thus a *mutual selection* by host and germ in constant operation; by the results of their reaction is determined how many of the individuals of each race will live and propagate their kind, or be exterminated, under the conditions of the struggle as set forth. But whatever the final result, neither can remain unchanged, and in the case of both (if we look solely to the tissue cells of the host) these changes must be transmitted to descendants and modify their after life-processes. Thus we get, on the one side, a greater or less measure of immunity (local or general), or the evolution or the disappearance of disease, or changes in its type, and thus also we explain some of the problems of seasonal incidence, into which however the influences of the environment external to, and apart from, both, enter (see Chapter IV., page 165 and footnote). The results for the *species* (distinguishing between the human body as a whole and its individual components) will, of course, be greater on the microbe owing to the incredible rapidity of the generations with the transmission of acquired traits, which, in the writer's view, goes far to settle the difficulty of the transmutation of species in the case of these unicellular organisms, for which,

* On one side we have the parasite, conditional or true, with other filth organisms (mixed infection) with, possibly, putrefactive matters; on the other side, the local tissue cells, epithelial, mucoid and lymphoid, the last named bringing the local tissues into connexion with the general system of the host, which is also the environment of the local tissue cells.

indeed, evidence is not wanting in the case of the highly specialized cell-constituents of the higher organisms. Such transmutations are not easily recognized and substantiated in the Laboratory for obvious reasons, but they need not therefore be excluded from our philosophy: we merely recall the prevalence of diarrhœa before and during a cholera epidemic, the relations of varioloid to small-pox, of sore throat to diphtheria, of "*typhoidette*" (? Simple Continued Fevers) to Enteric, as well as our ignorance of the operation of "mixed infections" (symbiosis). Long ago, Burdon Sanderson and Klein proved "that no line of demarcation can be drawn between inflammatory processes that clinically are 'non-infective' and those which are 'infective' like septicæmia and erysipelas," a statement that holds good to-day, when the various infective processes have become classified according to the different "species" of bacteria with which they are associated.

The tissue-cell and the bacterium alike works each in its own interests and is adapted to its specific functions and life conditions,—to evolution or to regression equally, in accordance with those conditions, and thus in the case of bacteria we must expect a constant passage from the saprophytic to the parasitic stage and *vice versâ*, and also constant fluctuations in the vital properties of the tissue-cells in direct touch with the environment. Two cardinal facts, in apparent opposition, have to be kept in view, *viz.*, Variation, and the persistence of Type. The source of variations must be sought in the relations of the germ to the environment, which are essentially nutritional; in a word, they are due to inequalities of nutrition to which the germ is subject (Weismann and Spencer; though the former invokes also amphimixis, a view which cannot be sustained). And we have already indicated how this influence operates in time (season) and place. (See Vernon on "*Variations in Animals and Plants*"; and the results of laboratory experiments, which show how the so-called "specific" properties of bacteria are lost and renewed by artificial "culture," and by the passage through animals.) The fact of the persistence of type is apt to confuse the issue and to lend support to the doctrine of immemorial "specificity"; the types that persist are those definitely adapted to a constant environment,—either saprophytic or parasitic. The bacteriologist sees only the end result; he finds a definite type constantly present in Enteric Fever *after* the reaction is set up, but he does not see the transition stages, as these naturally tend to disappear. The diseases suspected of what is called *de novo* origin are those generally included in the "filth" category, and this is explained on the facts set forth as regards the primary function and sources of nutrition of the parasites involved.

In the writer's opinion these facts and considerations should give pause to the doctrine of the immemorial "specificity" of disease "causes" which is largely based on a false analogy (from the case of multicellular organisms) and on the results of the artificial methods of the Laboratory, though even these are not devoid of suggestive hints which may soon bear fruit. At any rate, we must hold that it is less necessary than is commonly taught to invoke in Enteric Fever the access to the body of the *b. typhosus* in its full pathogenic panoply, and if, therefore, we may not regard as improbable its evolution from an allied and lowlier form within the intestine, we may find in the absence of the conditions which favour this evolution, or in the presence of conditions inimical thereto, some of the essential factors of immunity.

(5) Whatever be the factors operating to effect immunity, they must be bound up with the vital chemistry of the tissue-cells, and this is dependent on their reaction with the environment, food, etc.; but both inborn resistance and predisposition in the individual is relative, and a *potentiality* only which the environment may either develop or suppress. The same conditions apply to individually acquired immunity, whether it be general or confined to certain local tissues. The limitations to our concept of "specificity" must also extend to that of immunity; it is well known that the simultaneous injection of anthrax bacilli and the products of the *b. pyocyaneus* prevents the lethal effect of the former (Kanthack). In the case of Enteric there is the possibility of the enhancement of local tissue resistance from experience of its generic allies. We cannot ignore the close biological affinities of the whole *Coli* group; the original type being adapted to commensality and possibly to symbiosis with the intestinal cells, while some of the varieties are distinctly associated with the function of putrefaction. There is next the definite gradation of pathogenetic properties linking the varieties from end to end of the series, the reactions, both local and general, having certain fundamental characteristics in common. The lesions produced in artificial experiments by inoculation of the original harmless type, *b. coli*, have the closest likeness to those resulting from

spontaneous Enteric infection in man. We know that effective infection by one member of the group favours the growth and virulence of the others that may be present and that, conversely, immunity acquired against one has the opposite effect. (Sanarelli, confirmed by Escherich; Kolle and Wassermann.)

While then, when both are present, the one may supplement and aid the pathogenic force of another, a more or less exclusive experience of one may well be expected to afford a measure of protection from another, just as an effective antitoxin, in the "negative phase," actually lowers resistance temporarily which is subsequently established.

Further, characters that appear late in the ontogeny need not necessarily be referred to the category of "acquirements," as is seen by the results of the simultaneous exposure of adults and children of the same race to infections of which they have no previous experience.

(6) Lastly, we cannot disregard the indications of the phenomena of endemicity and of epidemicity in regard to an infectious disease of rapid onset, definite course and marked clinical features. These phenomena must be interpreted in the light of the considerations adduced, *i.e.*, in terms of the host, the parasite and the environment. We shall observe the greatest contrasts in accordance with the varying operation of these factors, and inasmuch as all the external conditions are most favourable to the prevalence of Enteric Fever among the natives,. we must regard the absence of these phenomena (save, perhaps, in certain well-defined localities where the circumstances are peculiar) as involving the absence (in some degree) of one or other, or both, of the other factors as effective agents.

If, moreover, the foregoing conclusions be valid we have an explanation of what may be called endemic immunity, apart from that conferred by a previous attack of the disease. Where a filth disease is endemic, the ancestral and allied saprophytic forms of the parasitic agent must be present in abundance and these, by reason of their identity of vital function, may surely be expected to confer a measure of protection against it, without producing obvious pathogenic effects, or only such as are of a lower morbid degree (*e.g.*, say, transient diarrhœa). Such an assumption is but a valid deduction from the postulate that the processes of infection and immunity are not contraries but correlates. This would also explain the phenomenon of the loss of a measure of immunity incurred by interruption of the relations of the host to the locality by periods of absence therefrom, and also the greater liability of immigrants on first exposure to the environment.

CHAPTER IX.

Enteric Fever among Natives of India and of other Tropical and Sub-Tropical countries.

Part II.—The evidence detailed and analysed. Conclusions.

It is now necessary to survey the evidence for the existence, and of the extent of the prevalence, of the disease among the natives of India. And it will be advisable to deal first with the communities under competent medical supervision and control, of which the native army and the prisoners provide exceptionally favourable examples. In the former case, we have a body of men in the prime of life, drawn almost entirely from the agricultural population, the average strength on duty being about 127,000, while, on the average of recent years, about 20,000 are enlisted annually to keep up the strength, the ages of these recruits ranging from 18 to 25 years; it is, therefore, probable that nearly one-half of the force exposed is comprised within this age-period.

These men are of course subject to the conditions and vicissitudes of the service in peace and war; they come for the most part from small isolated village communities to join a large body of their fellows aggregated, as a rule, in cantonments in the neighbourhood of the largest urban centres, to which they have constant access. They live, in peace time, under conditions approximating fairly closely to those of their homes, save for the inevitable aggregation and the common use of latrines, but they prepare and partake of their food separately, or in small messes of their own making, and the sanitary conditions generally are undoubtedly on the whole superior to those of their surroundings or of their villages. It must also be noted that they do not by any means necessarily serve in the areas of their origin and of their natural habitat, and that they are markedly susceptible to any considerable changes therefrom; further, in very many cases, native corps units are cantoned with European troops, but of course in separate "Lines." When on active service, they are still more exposed to an alien climate and environment and to contact with European troops, but at the same time, the conditions of life in camp tend, in some ways, to involve a closer return to their normal habits and customs in civil life.

The prisoners are also most largely drawn from the village population, but there is a far larger proportion of urban residents among them, and, save for the expatriated convicts, they are generally incarcerated in or near their ordinary habitat. While, in the mass, they represent the dregs of the population, the poorest and the feeblest in physique, whom in many cases destitution has driven to crime, there is also a large proportion of the best specimens of the peasantry who vie with the native troops in physique. The average total prison population in India may be put at about 110,000, but nearly 450,000 pass through the jails every year. This large flow necessarily enhances the risk of the introduction of infectious disease ; and the aggregation of the prisoners in common dormitories and factories, and their use of common latrines and food and water-supplies must favour its propagation and spread if introduced. The sanitary arrangements of these institutions is for the most part admirable, though they are carried out by the native prisoners themselves under the supervision of a single European medical officer in each case, nevertheless about one-fourth of the total mortality (which has steadily and very markedly decreased during the last fifteen years) is referable to Dysentery and Diarrhœa, while as much as 70 *per cent.* of the total mortality must be ascribed to specific communicable infections. This serves to show that, given the introduction of infection, the circumstances are certainly not inimical to its dissemination, and the etiological affinities of Dysentery and Enteric Fever must not be overlooked in this connexion.

Now as regards the age-constitution of the prison population the returns are blank, but the Inspector-Generals of the Punjab and Bengal have kindly furnished the writer with the results of a census taken in all the jails under their control, 76 in number, and accommodating in the aggregate, at the time of the census, some 30,000 prisoners. This census shows that a little over 18 *per cent.* of the total were under 25 years of age, while 40 *per cent.* had not exceeded their 30th year. We may now give in the briefest form a comparison of the incidence of Enteric Fever on the three different classes under medical control for a period of 22 years (1877-1898), which is chosen on the ground that it represents the period of recognition and of rising prevalence to the maximum recorded in the case of the European troops.

TABLE LV.

Enteric Fever. Admissions and Deaths in mean ratios per mille, 1877-1898 (22 *years*).

	1877-87.		1888-98.		Combined Period 22 years.	
	A.	D.	A.	D.	A.	D.
European Troops	9·3	3·21	23·6	6·29	17·0	4·88
Native Troops	·2	·11	·2	·08	·2	·09
Native Prisoners	·2	·10	·3	·11	·2	·10

We may add, at this point, that the mean *death-rate* for England and Wales, 1891—1901, of males between the ages of 15 to 45, was 0·277 *per mille* of the population at those ages, and the morbidity-rate may fairly be estimated at about 1·6 or 1·8 *per mille.*

It will be noted that the great increase shown in the second half of the period for the Europeans is absent from the record of the natives; that the incidence on the native troops and prisoners for the whole period is practically identical, an important fact in view of the objection that has been raised to the validity of these figures on the ground that, as regards the native troops, the diagnosis depends almost entirely on the clinical signs, and that many cases and deaths from Enteric Fever are possibly included among other fevers under the heads, *e.g.*, of Simple Continued and Remittent fevers. But to this the answer is that careful *post-mortem* examinations are made in the great majority of fatal cases occurring in the jails, and, indeed, in all cases in which there is any question of the cause: the reports on the results of these autopsies are, moreover, submitted for scrutiny to the administrative authorities.

But this question has an important bearing on the main point, *viz.*, the relative immunity of the natives of India to the disease, for, if true cases thereof are confused with the other common continued fevers, we should expect to find evidence of this in the combined mortality from all fatal fevers, and we may examine the data on this account.

TABLE LVI.

Mortality from Fevers, Dysentery and all Causes among Europeans and Natives. Mean ratios per mille *of strengths.* 1891-1900.

1891-1900.	1 Enteric Fever.	2 Other Fevers, Remittent, Intermittent & S. C.	3 Combined rate, all fevers, Col. 1 *plus* Col. 2.	4 Dysentery.	5 All Causes.
European Troops ...	6·46	·73	7·19	·87	16·21
Native Troops	·09	2·02	2·11	·59	12·22
Native Prisoners ...	·12	2·07	2·19	6·81	30·29

The contrast shown in Column 3 must be held to refute absolutely any suggestion of a gross error on account of diagnosis, so far as the possible confusion of Enteric Fever with the diseases in column 2 is concerned in view of the fact that the Europeans are equally, or still more, liable than the natives to attacks of these "other" fevers. The death-rate of European troops from *all fevers* (Column 3) is nearly three and a half times greater than that of the natives under medical control, and it would appear that, whatever be the true nature of the Remittent and Continued fevers from which the latter die, adult natives are far less liable to true Enteric infection. And even if we add the mortality from dysentery to that of *all* fevers we find that in the case of native troops the contrast is actually enhanced, the European troops being at a disadvantage to the extent of no less than 5·36 *per mille.* There are sufficient reasons for the excessive mortality among the prisoners from dysentery, as they are largely drawn from the dregs of the population, who rarely get adequate or proper nourishment and who suffered all the rigours of privation and consequent disease during the famine years included in this period : moreover, as has been said, any possible doubt of the true etiology of fatal disease among them is discounted, if not altogether obviated, by *post-mortem* confirmation of diagnosis. While, then, fevers cause fully 44 *per cent.* of the total mortality recorded for the European troops, we see that the ratio is only 17 *per cent* in the case of the native troops with a far lower death-rate from all causes, and that it amounts to only 7 *per cent.* in the case of the prisoners, who represent the most sickly and susceptible class of the indigenous population, aggregated under conditions that favour all the risks of the spread of infection. It may be that an uncertain amount of Enteric Fever does, indeed, escape recognition here as in the best regulated and attended communities in the West, but granted the utmost possible oversight, it will be allowed that the facts point to only one conclusion, *viz.*, that the disease is relatively rare among the adult native population. And on the other hand, there are not wanting facts which might be pressed in favour of the view that any defect in the record is compensated largely, if not entirely, by the inclusion of cases for which a true Enteric origin cannot be substantiated. Animadversions on the authenticity of the record from certain of the jails that have consistently furnished cases are to be found in the Sanitary Commissioner's (India) Reports, and it has been suggested that the personal equation of the Officers responsible in these cases has to be taken into account. Again, as regards the incidence on the native troops, we shall see that a very large proportion of the cases are reported from the Gurkha regiments, the average strength of which is only about one-thirteenth of the whole army. The Gurkhas are not only racially distinct from the Indian sepoy, but they are aliens and sojourners in this country, and as large consumers of meat and alcoholic stimulants, they differ in important respects from the majority of natives of India.

But, before stating the facts in this connexion which will find their place in a closer and more complete analysis of the records, a few remarks of a more general application are called for. And first we may allude to the significance of the higher mortality from non-Enteric fevers to which adult natives are subject when compared with Europeans. There is a remarkable similarity in the incidence of morbidity on the three classes compared, from Intermittent, Remittent and Simple Continued fevers, the only notable variation being in the respective liability to the last-named,—the mean admission rates (1891-1900) being 35·4, 9·1 and 24·0, for European troops, native troops and prisoners, respectively. But the different conditions under which febrile disorders are reported and under which treatment, including change of climate,* is carried out must

* When a sepoy is seriously ill he frequently obtains leave to go to his home before diagnosis is established.

be remembered in the results of treatment (or no treatment): the European is at a distinct advantage in these respects, for, in the case of natives, attacks are not only frequently complicated with some other disorder, but they come under treatment at a later stage or, in the case of the prisoners, are admitted to the jails in an advanced stage and in a very debilitated condition. But apart also from severer forms of Malarial infection to which the conditions of life of natives render them liable, the results in them are very largely due to complications, recognized or unrecognized, such as pneumonia, tuberculosis and the continued fever associated with the Leishman-Donovan bodies, to all of which natives are specially subject, the pneumonia rates being fully four times higher in their case than in that of the European troops, and the case-mortality much heavier. The robust native adult, as seen in the native army, finds his greatest enemy in Lung disease, which, even as tuberculosis, assumes a more or less acute form, while the same disorders are only little less fatal to the more debilitated classes from which the prisoners are drawn than specific bowel diseases, chiefly dysentery. These disease, complicated with Malaria, generally give rise to a remittent or continued type of fever under which head they are undoubtedly too frequently returned. Major Sutherland, I.M.S., Professor of Medicine at Lahore College, assures me that he is frequently called in for consultation in cases of severe "Remittent" fever, which do not react to anti-malarial measures, and in which he is generally able to establish a diagnosis of tuberculosis or pneumonia. This is in consonance with the seasonal and local distribution of "Remittent" fever, by far the most fatal of the three forms classed together in this discussion, the fatality and the case-mortality alike being greatest in the winter months.

This opens up the difficult problem of the manifold etiology of the cases returned under this head, and of the possibility of their confusion with Enteric Fever, from the clinical and *post-mortem* evidence, by hasty observers. We shall deal with this subject in discussing the criterion of diagnosis and, later on, when we come to review the evidence for the prevalence of the disease among the civil population (see page 475). We shall see that, apart from true malarial remittent, there are many other pathological causes in frequent operation to account for the fatality, and to open the way to a confusion of diagnosis, without invoking the unrecognized prevalence of Enteric, and its inclusion in the category of Remittent Fever.

It may be added that the mortality recorded from the three non-Enteric fevers has declined very noticeably during recent years owing doubtless, in some measure, to more exact diagnosis ; and this is equally true for both Europeans and natives under observation ; thus:—

TABLE LVII.

Combined Death-rates from Intermittent, Remittent and Simple Continued Fevers.

	Ratios per mille.		
	European Troops.	Native Troops.	Prisoners.
1891-1900 ...	·73	2·02	2·07
1901 ...	·58	2·26	1·52
1902 ...	·70	2·06	1·89
1903 ...	·49	1·55	1·31
1904 ...	·34	1·15	1·32

Now the mean death-rate from Enteric Fever in the two native classes was ·1 *per mille* in 1891-1900, and for the last four years it has been as follows :—

TABLE LVIII.

Enteric Fever, death ratios per mille *among Natives.*

	1901.	1902.	1903.	1904.
Native Troops ...	·12	·10	·22	·13
Prisoners	·17	·13	·25	·13

There is thus a remarkable similarity in its extent and in its slight variations ; but there is little to show that it is influenced materially by the extent of the mortality recorded from the other fevers ; the fall noted in the rates from these other fevers in 1903 and 1904 is accompanied by a rise in the Enteric rate in 1903 and by a considerable fall therein in 1904. The decline in the "other" fever rates is, moreover, not counterbalanced by a rise in the Enteric rates; thus, combining the mortality from all four heads we get:—

TABLE LIX.

Combined Death-rates, Enteric Fever plus *"other" Fevers.*

	European Troops.	Native Troops.	Prisoners.
1891-1900 (mean)	7·19	2·1	2·17
1901 ...	3·90	2·38	2·69
1902 ...	4·99	2·16	2·02
1903 ...	4·68	1·77	1·56
1904 ...	4·10	1·28	1·45

The great similarity of these results from different large bodies of natives scattered all over the country is very striking and significant, but the analysis is entirely against the assumption of either a large amount of fatal Enteric Fever or of the concealment of this under other heads.

It is to be noted that the *Remittent* fever rates are consistently lower among the prisoners than among the native troops, but there is no corresponding excess in the Enteric rates among the former. Methods of diagnosis may undoubtedly affect the contrast in the Remittent rates in the different classes; there are fewer cases in proportion to strength diagnosed as Remittent fever among the prisoners, and there is a higher case mortality of those so diagnosed than among the native troops, but the Enteric rates are practically identical in the two classes; and as regards fatal cases of both diseases among the prisoners, the great majority are submitted to an autopsy, which should preclude any large source of error.

> "There is a notable tendency on the part of medical officers to attempt to diagnose intractable cases of fever under some more exact and definite heading than that of "Remittent fever," just as there is a tendency to exclude from the category of "Ague" ephemeral cases in which the fever is but a result of digestive disturbance, or of exposure to the sun, and it is to be expected that this tendency will be reflected in the returns in higher rates on account of Enteric and Simple Continued fevers at the expense of Remittent fever and Ague." *Annual Report, Sanitary Commissioner, India*, 1904.

And, after all, the safest criterion of the extent of prevalence in this case is that of the mortality. It is remarkable, moreover, that, till within the last two years of the record, there has been very little sign of an increase in the prevalence: *e.g.*, in the native army, the mean rates for the period 1880-94 (15 years) were for admissions, ·22, and for deaths, ·08, while for the next eight years, 1895-1902, they were ·27 and ·09, *per mille*, respectively. In 1903 and 1904 the morbidity reported was equal to ·6 *per mille*, while the death rate in the former year was ·22, and in the latter ·13. Obviously, we cannot base a demonstration of increased prevalence on the experience of two years only.

Again, it is impossible to evade the question raised by the case-mortality from Enteric fever among the natives, for not only, as the figures given show, is it relatively high in comparison with any European standard, but it fluctuates from year to year to a very marked degree; *e.g.*, among the native troops, taking the mean for the decade 1895-1904, it was 33 *per cent*; in1901, it amounted to 58 *per cent*; in 1903, to 34 *per cent*; and in 1904, to 23 *per cent*, corresponding in the two last years to a rise in the admission-rates. Among the prisoners, taking the mean for 1895-1904, it was 38 *per cent* with very similar fluctuations. These results may be accounted for on the hypothesis either of non-recognition of the disease, or of its rarity in the present and in the past experience of the people; we shall have occasion to criticize the criterion of diagnosis and we still await a conclusive, scientific demonstration of the true extent of prevalence. (see p. 443).

Lastly, the age factor can scarcely be invoked to explain the difference in respect of Enteric incidence between the native and European troops; we know that about 20,000 recruits between the ages of 18 and 25 years are drafted into the native army every year and that the average period of service is not much over 7 years. We have seen, further, that the proportion of prisoners under 30 years of age to the total is about 40 *per cent.* Let it be granted that, in regard to the age factor and the susceptibility it connotes, both native troops and prisoners are at an advantage, and it will still be allowed that this cannot account for more than a small part of the great contrast in liability which they exhibit when the incidence of Enteric is compared with that to which the European troops are subject.

In passing from this discussion of the significance of Remittent and Simple Continued Fevers, it may be remarked that a perusal of the *post-mortem* reports of fatal cases lends no support to the presumption that they are of Enteric origin, though pulmonary lesions are very common.

Finally, a word or two may be said on the subject of the criterion which ordinarily and chiefly determines the diagnosis of Enteric fever, *viz.*, ulceration of the glandular structures of the small intestine. It is to be regretted that too often, instead of a detailed description of the lesions actually present, there is merely a statement that "typical typhoid lesions" or ulcers were found. In many cases the records give the impression that every ulceration of the intestine, not considered dysenteric, is put down as "enteric," regardless of the fact that even in Europe many different kinds of intestinal ulceration are recognized (see Rindfleisch, Klebs, Ziegler, Curschmann, &c.); while in India the pathological states promoting the necrotic lesion are still more abundant, as, apart from dysentery, we have to take account of the effects of pernicious malarial fevers, of tubercle, of the disease caused by the Leishman-Donovan bodies and of syphilis. Follicular inflammation when not specifically "Enteric," is doubtless most common in the large intestine, but it is one of the striking differences between the Enteric lesions found *post-mortem* in India and those of Europe, that in the former the large intestine is not only frequently described as affected, but has been even often described as solely or chiefly affected. Follicular dysentery often accompanies or follows an attack of Malaria, and in regard to diagnosis much may then depend upon the stage at which the lesions are seen *post-mortem.* It is to be noted, however, that while in some cases the lesions described appear to be too extensive and irregular to be characteristic of the Enteric process, there are frequent instances in which the clinical symptoms point strongly to the specific diagnosis and yet no trace of local intestinal implication is subsequently discovered,—owing possibly to enhanced toleration and resistance of the local tissues while the system is fully affected by the specific toxins, or, possibly, to paratyphoid infection. But even inflammation and necrosis of Peyer's patches is not necessarily diagnostic, as this may occur in simple sewer gas poisoning and in ordinary fæcal toxication at the instance of *b.coli* or other common fæcal saprophytes when the local conditions are abnormal and tissue resistance is reduced. Further, tubercular inflammation begins in Peyer's patches or in the solitary follicles, and it is asserted on good authority (Allbutt's "*System*") that tubercular ulcers occur in more than 50 per cent. of the fatal cases of Phthisis. The death-rate from tubercular Phthisis is exceptionally high among the natives, the means for the decade, 1891-1900, being for European troops ·55, for native troops ·61, and for prisoners no less than 2·98. Of the latter class a very large proportion are admitted into the jails with the disease (thus showing its prevalence among the general civil population*) and an analysis of 294 fatal cases which occurred in the jails in 1903 showed that the average duration of the illness in each, from the date of recognition until death, was only 70 days. While this may be due largely to non-recognition in the early stage, there is undoubted evidence of rapid progress of the morbid process, the local results of which may well deceive any but an expert pathologist, especially in cases dying from an intercurrent attack of Malarial Remittent. Any one on the look-out for Enteric fever would be likely to find confirmation in the *post-mortem* evidence in such cases. This aspect of the question is even more justified in the case of native children surrounded by tubercular infection—coughing and spitting being rather a normal function in the native than an exceptional, dirty habit—under the conditions of life and hygiene in which they are reared. While then, it is not true that among the forms of continued fevers occurring in Europe, specific Enteric Fever is the only one characterized by the presence of intestinal lesions (in Peyer's patches and the solitary follicles) it is still less likely, having regard to the functions of the lymphoid tissue, that this should be the case in India, but it is nevertheless probable that the almost exclusive association of this lesion with Enteric fever in England has had the effect of deflecting the judgment of observers in this country. With the provision of resources for research, we should not be left longer in doubt upon the matter, and apart from the routine application in capable hands of the serum reaction now rarely employed (and which should be applied to all the prominent members of the Typho-Coli group) there is an urgent call for the identification of the effective bacillus or bacilli in the tissues and secretions of all probable and doubtful cases until the main question is conclusively settled.†

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* In Bombay City the death-rate from pulmonary Phthisis was equal to 9·4 *per mille* of the population in 1899-1900 and in one Ward (pop. 130,000) it rose to 16·4 *per mille*.

† In only 20 cases out of a total of 70 reported in 1904 (native army) was the Widal test employed, with alleged "positive result" in 14; but in only 3 cases was the dilution stated.

It is important to note that Dr. Row of Bombay, formerly Assistant to Professor Sidney Martin at University College, London, has reported his success in inducing Enteric lesions in rabbits and rats by means of the intravenous injections of the toxins of *b. coli* ; and further, that in a series of cases of continued fever of an irregular type, closely simulating Enteric Fever in general course and symptoms, which is common among natives in Bombay, the results of the serum reaction indicated very definitely that *b. coli* was in the majority of cases the *fons et origo mali*, while *b. enteritidis* (Gaertner) appeared to be the effective agent in others ; in only two of the 24 cases summarized did the evidence point to a pure *typhosus* infection. A relapse in one of the two latter cases appeared to be due to Coli infection following on the true Enteric attack. He concludes that the blood serum in these cases, which many observers would describe as Enteric without qualification, acts powerfully in a lysogenic manner, upon the bacilli of the Typho-coli race and that the reaction appears to be specific or "primary" in regard to one or other, or occasionally to more than one, member of the group. The facts appear to support the accepted view of the close biological affinities of these organisms, and also the corollary hypothesis of their evolution from one common type.

These observations, which deserve careful consideration, are the more important in view of an altogether independent statement made from the clinical standpoint (and one of large experience) by Colonel Crombie, I.M.S., in his address before the British Medical Association in 1904 ; we quote his own words.

"In my address of 1894 (to the Indian Medical Congress) I spoke of a continued fever, which ran the course of a mild typhoid, of from three to four weeks' duration, but which had none of the clinical symptoms of that disease. It had been recognized as *a peculiar type in all the larger towns of India*, where it was known by the local names of "Calcutta fever," "Bombay fever," etc. In the absence of specific evidence that it was no other than typhoid, we declined to give it this name, although we treated it as such. I provisionally called it "urban fever" in 1894, but am now prepared to regard it as a peculiar form of typhoid, and in my paper in the *Encyclopædia Medica* I have suggested the alternative name of "Bastard typhoid." My reasons for advancing it to this category are that in one case, which I had an opportunity of examining before I left Calcutta, I obtained the Widal reaction, and as this is a fever of Europeans, the same objection does not exist to accepting this evidence as it does in the case of natives. Major Rogers also states that he found this reaction in every case of continued fever in the wards of the European General Hospital." (See later) "It would have been more satisfactory if he had sorted the cases clinically, so as to have been able to make it quite clear that his enumeration included cases of this type, for the fact that they conform to the serum reaction of typhoid fever in no way alters the fact that they exist as a distinct clinical type. It has been demonstrated that there are several types of enteric fever and a form which does not give the serum reaction in any period of its course has been pointed out under the name of "paratyphoid". And I think that the distinct clinical type which is so well recognized in India, and which I have called "bastard typhoid," ought not to be dismissed because it gives the serum reaction, but its peculiar clinical features rather mark it for more exact research. My experience in connexion with the typhoid fever of the South African war, which showed several very distinct deviations from the ordinary classical enteric of the text books, namely, the often copious eruption, the frequency of thrombosis and of muco-enteritis as a sequela, has led me to think that typhoid fever is generally a mixed infection, the symptoms and severity varying with the amount and quality of the mixture and it is not impossible that the peculiar type which occurs in the large cities of India may turn out to be a pure infection with Eberth's bacillus, and may thus form the bed-rock on which the more classical cases are built up by additions of other intestinal flora."

On this we need only remark at this point that whatever view be taken of the etiology of these cases in the light of Row's work, we may take leave to regard the early designation of "*urban*" fever as very suggestive and as constituting an important observation by a most experienced clinician, which may have a definite bearing on the etiology of Enteric and paratyphoid fevers as they affect the natives of India. (See later.)

We shall now touch briefly on a most important aspect of the problem as presented among the natives, *viz.*, the salient epidemiological features. Nothing is more significant of a relative immunity to the disease than the fact that anything in the nature of an epidemic (in the sense of Western experience) is unknown, and at the most we get, and this rarely, a small series of cases of the "house-epidemic" order, which may be referred to a common source or to contact infections. This essential fact is so well-established that we shall not waste space in its demonstration. For some earlier examples, which are quite typical of the whole record, we would refer the reader to the Reports of the Sanitary Commissioner (India) for 1890, 1891 and 1892. It is shown as regards the incidence on the jails for the triennium, that 64 cases were reported from 45 separate Institutions situated in all parts of India, the largest number reported from any one place being 4; for the native army the record during the same period is 107 cases returned from 56 regiments with the widest distribution in place, but of the total (107) no less than 37 were recorded in 1892 in four regiments of

Gurkhas, so that the other 70 were distributed over 52 separate corps. The bare statement that only 64 cases were recorded in 3 years among some million and a quarter prisoners passing through the jails, and that only 70 cases were recognized in 3 years among an average strength of about 120,000 men (excluding Gurkhas) is significant. If we take the last year of the record (1904), when Enteric was at its highest in the Native army we find that 70 cases were reported from 47 separate corps units, the highest number of cases in any one unit being 5, while there was only one case recognized in each of 31 of the units. The obvious corollary to these statements is the fact of the complete immunity enjoyed by the great majority of the prisons and of the corps units, both subject in a high but unequal degree to an influx of individuals from outside. The fact that the rates of incidence on both these different classes of the native population are not only so small but almost identical over a very long series of years, while one class is especially liable to the introduction of any existing infection from the fluctuating nature of the community, may be taken along with the absence of epidemic outbreaks to indicate the rarity of the disease among the general body of the free population. In this connexion those who are convinced that drinking-water plays the most important rôle in the conveyance and dissemination of the infection will find it difficult to account for this immunity on any other hypothesis than that of the absence of the bacillus in the environment, or that of special powers of resistance to attack, for no one can maintain that the water-sources of the people at large are not open to constant pollution with fæcal products, nor that the water in common use is not, as a rule, a highly charged solution of salts arising from the decomposition of human excretory products in which the associated bacteria find a congenial nidus and vehicle. On the other hand epidemics of cholera, dysentery and of fevers of the Remittent type are only too familiar ; as regards the first, and we may add the second, there is little probability of mistaking the nature of the disease, and for the second and third the seasonal incidence is quite peculiar and distinct in essential respects from that of Enteric, thus : (see next page).

The figures for Enteric Fever in the coast and true peninsular areas are so small as to preclude any useful comparison. But it is chiefly in the *mortality* from Remittent Fever that the contrast is most markedly demonstrated, for while for Enteric this is highest during the hot weather from April to August inclusive, for Remittent, the winter months from December to March yield the largest number of fatalities, the case-mortality also at this time being just double that recorded during the rest of the year.

TABLE LX.

Admissions for Enteric and Remittent Fevers and Dysentery by months, in the Native Army. Actuals, 1899-1903.

	Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sep.	Oct.	Nov.	Dec.
Enteric Fever...	10	10	9	29	30	18	12	22	7	7	9	13
Remittent ...	432	339	387	507	637	655	786	727	626	753	478	347
Dysentery ...	839	600	665	1,042	1,145	1,117	1,731	2,282	2,111	2,127	1,901	1,449

N.B.—Geog. Groups V., VI., VII., VIII., IX. and XII. (the "continental" area) alone taken.

One other aspect of the epidemiology in definite contrast with our experience in regard to the European troops deserves notice, and that is the immunity to the disease which is exhibited by natives of India serving or resident in other tropical or sub-tropical countries. It is somewhat remarkable that a general statement in the opposite sense has been published, but without evidence, (see Davidson's "*Hygiene,*" page 233); but the Army Medical Reports for the six years, 1890-1895, record no deaths from Enteric Fever among the Asiatic troops in China and the Straits and no mention is made of admissions. The records of the Perak expedition do not refer to the disease, and following up the record in more recent years we find the same statement applies to the Suakin Field Force (1896, to which reference has been made in a previous Chapter,) and also to the force maintained in Mombassa from 1896 to 1899; also to the Ad Dariga (1901) the Ogaden (1901) and the Somaliland Field Forces (1902-03), to the Tibet Mission force (1903) and to the Indian Coronation Contingent (strength 1012) when in England in 1902; in none of these bodies of Natives on foreign service was a single case reported. During the thirteen months (1900-01) that the China Expeditionary Force was in being, there were, among an average strength 12,097 men, 3 cases and 1 death recorded, giving ratios *per mille* of ·2 and ·08 respectively, which is the average incidence recorded in India. The Aden Column (average strength 983) exposed throughout the year 1903, furnished three cases (no death), a ratio of 3·1 and this is the only instance of a notable increase over the Indian rate and can surely not be quoted against the results cited, for if the experience of the same force in 1904 be included the ratio falls to only 1·8 per mille over the whole period of two years. And it must be remembered that the forces above-named were constituted on a war footing with all the manifest disadvantages pertaining thereto. Again, to take the evidence from the operations conducted across the Indian Frontier which we need not discuss *seriatim*, and in which since, and including, the Afghan campaign (1879-80) there have no less than 25 separately constituted forces employed, we find that in only three instances was Enteric Fever reported; *viz.*, in the Afghan war, the admissions amounted to ·5, and the deaths to ·19 *per mille*; in the Chitral Relief Force (1895) the rates were ·3 and ·3, respectively, and in the Tirah-Kohat-Mohmund campaign (1896-97) they were ·5 and ·2 respectively. Throughout the 24 years with as many expeditions on a war footing there were only 33 cases and 14 deaths recorded on this account, of which 26 and 10, respectively, occurred in the Afghan war 26 years ago, since when critical care in diagnosis has greatly increased.

As regards the troops employed in garrison duty abroad the record is very similar; no cases nor deaths from Enteric fever have been reported from the garrisons of Colombo (1900-03), Kandy (1900-02), Trincomalee (1900-02), and Singapore (1900-03); and in Mauritius, in which the average strength has ranged from 550 to 1,611 from 1898 to 1903, there has been only one case during the six years in question. Lastly, in the China garrison (1901-1903), in which from two to nearly four thousand troops have been maintained, there have been three cases and three deaths recorded. Allowing for the high case mortality it can certainly not be said, in view of the whole record cited, that Natives of India lose their relative large measure of immunity when exposed to a foreign environment.

As regards Natives of India who emigrate for labour to the West Indies and elsewhere, we have statements from local medical men to the effect that the disease is rare or non-existent among them; *e.g.*, in British Guiana (though Dr. Law has described 2 cases that *may* have been Enteric fever, but the intestinal ulceration on which the diagnosis was based was admittedly far from typical, *Journ. Trop. Med.* May 1899), British Honduras, and Ceylon; and as regards the last, Sir Allan

Perry, in his Annual Report, refers specially to the apparent immunity of the imported Indian coolies. Reports from the authorities of the largest steamship companies trading in the East confirm this general view in respect to the lascars they employ.

Upon the facts and considerations now before the reader the contention in favour of a relative immunity enjoyed by the Natives of India must stand or fall in the light of our present knowledge, and the issue is so important as to demand a brief summary of the argument.

(1). All classes under medical control (Europeans and Natives) suffer a fairly equal liability to *morbidity* from the forms of fever classed as Intermittent, Remittent and Simple Continued, but, on the whole, the European troops suffer most. As regards Enteric, the record for the latter is altogether disproportionately excessive in all parts of the country.

(2). We have a low and steadily decreasing *combined fever mortality* (including Enteric), in the two native classes, now amounting to less than 2 *per mille*, with a steady rise therein among the Europeans, due to the increase of Enteric (see Chart, Chapter II); the recent decline due indirectly to the Boer War, and its subsequent effects does not affect this proposition in its essential and comparative implications.

(3). So that, when we take the last decade (1891-1900), for which a comparison is valid, the *combined* fever mortality of the Europeans is nearly 3½ times that of the natives (7·2 against 2·1). It is difficult to account for the above three statements of fact on the hypothesis of a large and increasing amount of Enteric among the latter, who represent the population at large, but are under special conditions which, in certain ways, favour the prevalence of the disease, and which tend to secure its recognition during life and after death.

(4). We see the remarkable similarity in extent of, and in the slight fluctuations in, the mortality rates from Enteric and the "other" fevers, respectively, among the two native classes under the medical control of a large number of different officers who are constantly changing their charges. The Enteric rates remain practically unaltered during the last 30 years, while the mortality from "other" fevers has steadily decreased to one-half in the case of the native troops, to one-third in that of the prisoners. There is no valid reason for this decline if "other" fevers include any notable proportion of Enteric. Then the fact that the record distinguishes so clearly between the incidence on Gurkhas and that on natives of India may be held to show that where Enteric is comparatively more prevalent, it is recognized, and this serves to confirm the negative record in the Native army, apart from the Gurkhas.

(5). The age-constitution of the native classes under medical control cannot be invoked to explain more than a small proportion of the relative immunity they enjoy. There is, moreover, no increased susceptibility derived from exposure to an alien environment (troops on service out of India; Indian coolies abroad; campaigns); save, possibly, when brought into contact with the largest urban communities.

(6). The criterion of diagnosis (intestinal ulceration) is open to fallacies on account of the frequent presence of this lesion in other febrile disorders so prevalent among the natives, which also resemble (more or less) Enteric in their clinical manifestations. This serves to enhance the record of Enteric at this stage of the endeavour to differentiate the class of "Remittents," and this must be taken into account as a set-off against non-recognition of the disease. A discussion of this subject is reserved for a later page.

(7). The salient features of the epidemiology can only be reconciled on the assumption of a relative immunity from the disease.

(8). The most valid evidence of the general prevalence of the disease is derived from cases occurring in large urban centres—Bombay, Calcutta and Poona, where, it is true, they are more likely to come under skilled observation. But here the conditions (of comparatively recent origin due to the growth of an industrial civilization and of facilities for rapid railway communications under British rule) are quite peculiar and foreign to the vast majority of the people living in small, isolated village communities. These urban centres have attracted the more emancipated classes (as regards caste rules) for the educational advantages they afford, and in many respects the natural and immemorial habits of life are altered in the direction of the Western standard. Refer to Crombie's observations on "urban fever" and to the results of the Widal test in the hands of Rogers and Lamb (see page 452); as regards the entire validity of this criterion we shall have some remarks to offer later (Uhlenhuth on the precipitin test). The evidence, on the whole, as will be seen, is in favour of a special liability incurred by individuals who are subjected to the conditions which may be summed up under the term "urbanization" and all it connotes.

(9). The questions raised by the comparatively high case-mortality (fully 30 *per cent* as recorded for the native troops and prisoners) are important, and also difficult for lack of a conclusive, scientific demonstration of the true extent of the prevalence of the disease. We see this higher fatality (as compared with that on Europeans), a constant feature of the returns for "other" fevers, for pneumonia, tuberculosis and for dysentery; as regards "Remittent" fever the case-mortality ranges from 3 *per cent* among Europeans, to 8 among the native troops, to 12 among the prisoners. That for dysentery is 3 *per cent* among Europeans and 7 *per cent.* among prisoners, and so on. We cannot say how far the higher fatality of Enteric among natives is due to non-recognition of the disease among them, but we shall see that it is even higher among the Gurkhas in whom the disease is well recognized. Rogers' and Lamb's results as hitherto published (34 cases) yield together a case-mortality of 24 *per cent*, but many of Lamb's cases were among the classes who could afford skilled medical attendance, which in fact may be said to apply to all. But we must take into account the higher mortality and fatality of *all* febrile and bowel disorders among natives due probably to their conditions of life, *e.g.*, race and marriage customs, clothing, housing, &c., which tend greatly to lower resistance to infections, to which, moreover, they are habituated. It is also due largely to the complications which nearly always attend fevers and bowel diseases in natives (as we have seen in the case of "Remittents of various origin), and which find their chief seat in the lungs, which *post-mortem* examination rarely finds unaffected. Enteric Fever, be it noted, is fatal everywhere in proportion to the gravity of the complications, and the graver ones are just those from which the natives die chiefly, apart from Enteric infection, and notably from pulmonary diseases and thrombosis. As Curschmann remarks: "where distinct differences with regard to the mortality in an unfavourable direction are apparent, these depend especially on morbid combinations with other severe morbid states of local origin;" and he instances especially Malaria and respiratory diseases. The results of the active coincidence of Malaria and Enteric in the American camps was to raise the case-mortality from 7·6 to 33 *per cent.* Where malarial infection had preceded or followed the Enteric infection, the average case-mortality was doubled. We have also to take the age-factor into some consideration, as well as the debilitating effects of heat (the greatest incidence being in the hot weather), and the treatment to which rare sporadic cases, which are only recognized at a late stage, are subjected.

A high case-mortality need not therefore be inconsistent with a low morbidity rate to whatever cause this relative immunity to attack may be due; if racial, the high fatality may be accounted for by reversions to a more susceptible ancestral type (in addition to the causes above specified), and if the general immunity be purchased at the expense of attacks in childhood, those who escape the disease at that period should be very susceptible provided the effective germ gains access to them. But it is difficult to see how any susceptible person can escape to maturity if the infection is so widespread as to affect nearly all the children, when regard is paid to the customs of the people, in regard to the family bond and commensality, etc. It remains to say that many capable observers are entirely opposed to the view of a high case-mortality as supported by the records we have considered. But even if this be granted, and a full allowance be made for unrecognized cases, so as to bring the fatality rate down to, say, 10 *per cent*, the morbidity rate for Native troops and prisoners would still be well under 1·5 *per mille*, that is, among a population comprising a large proportion at the most susceptible ages.

(10). Lastly, we have to consider the whole body of evidence as recorded for all indigenous races in tropical and sub-tropical regions, which so far as it goes is invariably in favour of the contenton of a relative immunity from the disease (see conclusion of this Chapter).

We have already set forth the facts as to the incidence of Enteric and other Fevers on the Native troops and prisoners as integral classes, and as the rates fluctuate inconsiderably from year to year, we may now give some idea of the local distribution of the disease based on the records for the last decade 1895-1904, and then discuss briefly some of the salient indications to be derived therefrom. We shall then survey the evidence available in respect to the civil population, and all that follows from this point will, it is hoped, provide material for a provisional judgment on the main question as set forth in the foregoing propositions.

Taking first the Native army, the following statement shows how the incidence was distributed upon the different Commands :

Enteric and Remittent Fevers by Commands, Native Troops. Mean ratios for 1895-1904.

Command.	Aggregate Strengths.	Enteric Fever.		Remittent Fever.	
		A.	D.	A.	D.
Bengal	260,789	·6	·22	11·5	·83
Punjab	414,801	·4	·13	21·8	1·52
Bombay	259,636	·2	·06	12·7	1·01
Madras and Burma	223,180	·1	·03	5·6	·70
Hyderabad ...	51,642	*Nil*	*Nil*	11·6	·79
INDIA ...		·34	·11	14·2	1·09

It will be noted that there is no consistent relation between the Enteric and Remittent rates. And next, there would appear to be a notable excess of Enteric Fever (in comparison with the low average prevalence) in the northern and continental areas and this is undoubtedly the case. But this is largely, not entirely, due to the fact that the Gurkha Regiments (average strength between 10,000 and 11,000) are almost entirely located in the Bengal and Punjab Commands. It will be found that during the decade in question there were in all 430 cases and 137 deaths recorded for the whole Native army (average strength, 126,000), but that of these totals no less than 152 cases and 54 deaths occurred among the Gurkhas (average strength 10,864), so that we get the following results :

	Enteric Fever. 1895-1904. A.	D.
NATIVE ARMY, excluding Gurkhas (average strength 115,287) ...	·24	·07
GURKHAS (average strength 10,864)	1·4	·50

which indicates a six-fold liability to attack, a seven-fold liability to a fatal issue in the case of the Gurkhas, as compared with their Indian comrades. Now this has a significant bearing on the general problem of diagnosis ; the recognition of the special prevalence among the Gurkhas serves to confirm the negative results on record for their comrades, the natives of India. The disease is recognized but there is a remarkable contrast in the records for the different races under observation. If the cases and deaths among the Gurkhas be deducted from the results shown for the Bengal and Punjab Commands, we shall find the morbidity rate in these latter, combined, to fall to ·33 and the death-rate to ·10 which, however, still leaves the incidence very considerably higher than in the southern or peninsular area (Bombay and Madras Commands) just as was found to be the case with the European army. (Chap. IV). This result is the more significant inasmuch as they are furnished by totally different bodies of medical officers, *viz.*, those of the I.M.S., and the R.A.M.C., respectively. In explanation, we might with some reason expect that where the disease is most prevalent in one class and the sources of infection are most abundant, there also Natives in more or less close, if indirect, association would suffer to a greater extent, and this hypothesis would be in consonance with the view contended for in this Essay, that we need not look to the Native people and their environment to explain the prevalence of the disease among the European troops, but that the chief sources of infection must be sought for within the cantonments of the latter. We cannot ignore the probability of the danger to Natives from their association with Europeans, and we may affirm that there is much to be said in favour of this alternative, though it is directly opposed to the view which at present dominates opinion. (Chap. X). Reference has been made to Sandwith's suggestion that a recruit in the Egyptian army "becomes liable to a slight amount of Enteric Fever while he is in contact with Europeans." We need not press this point in default of more direct evidence, although facts of a confirmatory tendency can be adduced from other sides as we have seen in the case of the Native servants of European civilians, and as we shall see when we come to deal with the most authentic facts which are available in proof of the indubitable liability of Natives to the disease.

A part of this excessive incidence on the Northern areas may, possibly, be attributed to climatic causes (see Chap. IV) and to the fact that Native troops serving in these areas have been more liable to movements and to residence outside their natural habitat. It is also worthy of note that, apart from the

Gurkhas, the army of the North is recruited most largely from the fighting races, the Bengali and the "mild Hindu" being excluded from the ranks. A glance down the list of the castes that furnish the "sword arm of the Empire" will show, to anyone who is acquainted with the habits of the people, that, with the exception of a small minority of Brahmins, they all consume meat—though doubtless in inconsiderable quantities on a European standard on ordinary occasions, but still they are in this respect marked off from the great mass of the people, and the point is merely noted as suggestive. The theory that where the dietetic habits of Natives approximate to those of Europeans in respect chiefly to the consumption of animal food, we may expect to find a relative liability to the disease is, of course, of long-standing and took its rise from the experience of the excessive incidence on Gurkhas, who present the greatest contrast to the ascetic habits of other Hindus, with the exception of the lowest castes, who, however, are more often without the means of satisfying their appetite for "fine confused feeding." And until recently the available evidence went far to support this view. Dealing first with the Gurkha, we cannot exclude from account, the influence of his dietetic and alcoholic indulgence, if the views set forth in the previous Chapter possess any force. But there are doubtless other contributory factors, largely due to the rigorous climate of the hills upon which Gurkha regiments are cantoned; among these may be reckoned the neglect on the part of this admirable soldier of personal cleanliness, and the lack of adequate air-space in his barracks (which, with the lack of ventilation, accounts for his great liability to tuberculosis) which is most marked in the "married quarters" where there are children, and their diseases, brought into the question. A further cause of impairment of the function of the lungs (which however is common to the Native army as a whole) is the habit of sleeping with the head completely covered by a blanket which is rarely free from contamination by the soil and by excretory products. Now primary Typhoid pneumonia is anything but rare, as Captain McCarrison, I.M.S., has shown, and this is propagated by the habit of expectoration on the floors and walls of the dormitories, which moreover may afford a favourable nidus for the bacillus by the fact that they are constantly covered with a layer of moist organic matter in the form of a mixture of cowdung and clay. This surface constantly disintegrates and polluted dust must find ready access to the mouth and lungs. As regards the more direct methods of intestinal infection Captain McCarrison refers to the custom of cleaning the food vessels with the soil round about the barracks upon which urination is common at night, although receptacles are provided on the spots from which this soil is taken. Again, the situation of the latrines in relation to the open water-courses (in the hills) from which the drinking, bathing, and cooking supplies are obtained, is in some stations dangerous and invites pollution under the influence of rainfall. But after all, epidemics are rare, (though small outbreaks are commoner among the Gurkhas than among other Native troops) and the sporadic cases appear to be explained on the assumption of barrack and contact infection under the circumstances described, which in many respects differ from those under which Natives live in the plains, especially as regards closer aggregation and the use of common resorts. The Gurkha is notoriously sociable beyond his Indian comrades and indulges his appetites without restraint especially when in contact with European troops. It is notable that in most respects the vital statistics of the Gurkhas approximate in character much more closely to those of their European comrades in arms than do those of the Natives of India. But in a lesser degree, many of the conditions under which the Gurkha soldier lives are common to the Indian troops stationed in the continental area where the climate presents marked seasonal contrasts of heat and cold, and it is just in this area that Enteric is more prevalent. In 1895, the medical officer of the 44th Gurkhas at Manipur made the following statement : "the native Manipuris drink foul water with impunity and Enteric is unknown among them; I did not see a single case of the disease during four years' residence; they are almost entirely vegetable feeders. But the Wagas who live in the same valley are, like the Gurkhas, meat-eaters and I have seen many severe cases of the disease among them." (Report, Sanitary Commissioner, India, 1895).

In 1904, Enteric Fever had reached the highest point recorded in the Native army and as the incidence on the Gurkha regiments was exceptionally low, a statement showing the regiments attacked, the constituent castes and the localities occupied, will be useful and interesting in the light of the foregoing remarks : (see pages 449-50)

Enteric Fever in Native Corps units in 1904.

N.B.—M. = Musalmans; P. M. = Punjabi Musalmans.

Station.	Regiment.	Cases.	Deaths.	Castes or Races.
1. Manipur ...	7th Gurkhas ...	2	...	Gurkhas.
2. Fort William ...	18th Infantry ...	1	...	Musalmans.
3. Alipore ...	2nd Rajputs ...	1	1	Rajputs.
4. Dinapore ...	5th Infantry ...	1	1	Musalmans.
5. Fyzabad ...	62nd Punjabis ..	1	...	Punjabis.
6. Dehra Dun ...	Governor-General's Body Guard.	1	...	......
	2/2 Gurkhas ...	2	2	Gurkhas.
7. Ferozepore ...	7th Lancers ...	2	...	Jats, Sikhs, Dogras and Musalmans.
8. Mian Mir ...	23rd Pioneers ...	1	1	Sikhs.
9. Sialkot ...	40th Pathans ...	2	1	Pathans.
	47th Sikhs ...	2	2	Sikhs.
	46th Punjabis ...	1	..	Punjabis, Pathans and Sikhs.
10. Rawalpindi .	58th Rifles ...	1	1	Sikhs, Dogras, Pathans and Musalmans.
	17th Lancers ...	1	...	Punjabi Musalmans and Pathans.
11. Attock ...	25th Punjabis ...	1	...	Sikhs, Dogras, Pathans, and Punjabi Musalmans.
12. Mardan ...	Corps of Guides ...	1	...	......
13. Nowshera ...	54th Sikhs ...	1	...	Sikhs, P. M., Pathans and Dogras.
	Depôt 35th Sikhs ...	2	...	......
14. Peshawar ...	66th Punjabis ...	5	1	P. M., Sikhs and Rajputs.
	No. 2 Co., 1st Sappers and Miners.	1	...	......
15. Kohat ...	56th Punjabis ...	2	...	Sikhs, P. M., Khattaks, and Dogras.
16. Dera Ghazi Khan	22nd Punjabis ...	1	...	Sikhs, P. M., Pathans.
17. Deesa ...	31st Lancers ...	1	...	Jats, Sikhs, Pathans Mahrattas.
18. Baroda ...	119th Infantry ...	3	1	Goojars, Mers, Rajputs and Hindustani Musalmans.
19. Jhansi ...	40th Pathans ...	1	...	Pathans.
	67th Punjabis ...	1	1	P. M., Sikhs, Hindus.
0. Nowgong ...	18th Lancers ...	1	...	P. M. and Sikhs.
	37th Dogras ...	3	...	Dogras.
Sehore ...	9th Bhopal ...	1	...	Sikhs, Rajputs, M. and Brahmans.

Enteric Fever in Native Corps units in 1904.—(contd.)

N.B.—M.=Musalmans ; P. M.=Punjabi Musalmans.—*(contd.)*

Station.		Regiment.	Case.	Deaths.	Castes or Races.
22.	Mhow ...	108th Infantry ...	1	..	Musalmans and Mahrattas.
23.	Bolarum ...	99th Infantry ...	1	...	Rajputs, Jats, Musalmans.
24.	Kirkee ...	3rd Sapper and Miners	1	...	M., Sikhs, Rajputs and Mahrattas.
		107th Pioneers ...	1	...	Pathans, Musalmans, Sikhs.
25.	Shillong ...	8th Gurkhas ...	2	...	Gurkhas.
26.	Lansdowne ...	2/3 Gurkhas ...	5	2	Gurkhas.
		1/9th Gurkhas ...	1	...	Gurkhas.
27.	Kila Drosh ...	1/1 Gurkhas ...	1	...	Gurkhas.
28.	Malakand ...	57th Rifles ...	1	...	Sikhs, Dogras, M., and Pathans.
9.	Abbottabad ...	27th M. Battery ...	1	...	......
		1/6th Gurkhas ...	1	...	Gurkhas.
		1/5th Gurkhas ...	2	...	Gurkhas.
	Miran Shah ...	26th Punjabis ...	2	...	Sikhs, Afridis and P.M.
31.	Fort Sandeman...	37th Lancers ...	1	1	M., Pathans and Sikhs.
32.	Loralai ...	32nd ,, ...	...	1	(Remaining Case.) Musulmans, Rajputs, Sikhs.
33.	Quetta ...	26th Infantry ...	1	...	Sikhs, Afridis and P.M.
34.	Marching ...	124th Baluch Infantry	2	...	Musalmans and Sikhs.
35.	Sikkim Tibet Mission ...	....	2	...	
			70	16	

As regards the local incidence, it will be seen that 5 cases and 2 deaths were returned from Bengal proper, the most easterly area (Nos. 1 to 4) ; that 13 cases and 1 death occurred in what we may call Central India (Nos. 17, 18 and 20 to 24), while 52 cases and 13 deaths were distributed over the true N. and N.-W. continental area, including the Hills. The list of the castes speaks for itself as including an overwhelming proportion of those whose rules permit the consumption of meat, and who ordinarily avail themselves of it.

While dealing with this question we may refer briefly to some evidence derived from the civil population which, however, we shall not attempt to make exhaustive, merely presenting some typical instances from the most reliable sources. Colonel Browne, I.M.S., who was for many years Principal of the Lahore Medical College, made a statement in 1899 (published in the *Indian Medical Gazette*), which indicated the rarity of Enteric Fever among Natives of the Punjab, as only 11 cases had been diagnosed during six years out of over 1,200 patients admitted for fevers ; of these 11 cases, four died in hospital and in two the diagnosis was confirmed by autopsy. Beyond this the interest, in the present connexion, lies in Colonel Browne's expressed opinion that the disease has some relation to the dietary of the patients. Of the cases cited, two were in Native Christians, one in a man employed in a railway refreshment room, one in a schoolmaster of semi-European habits, and one in the cook of a European establishment ; all were meat-eaters and none bound by caste-rules. "Nevertheless, I have known the disease to occur in a Brahmin." He therefore inclines to the theory that the more closely the Native assimilates his diet to that of the European the more liable does he become to the disease. Major (now Lt.-Col.) Burke, I.M.S., who has a very extensive experience in civil practice in the Bombay Presidency has stated (*B. M. J.*, August 10th, 1901) that though the disease is rare in ordinary Natives of India, it has been recognized by him in several cases among Parsis and among members of the native aristocracy, the former having no caste and the latter being above caste prejudices. The question, however, is scarcely to be settled by such data, for the different classes of the people naturally avail themselves of hospital treatment and of the private services of physicians in different degrees. And when we regard the results of the cases submitted to very careful test by means of the serum reaction, as in the series published in the *Indian Medical Gazette* (1901-2) by Majors Lamb and Rogers, I.M.S., it must be admitted that the diet factor cannot be regarded as the sole determining predisposing influence. Lamb's series includes a total of 21 cases of whom nine were Brahmins, five Hindus, five Native Christians, one Parsi and one Goanese. Now these cases occurred mostly in Poona and Bombay cities, where Brahmins and Hindus form a relatively large proportion of the population, and the majority of the patients were students or in Government employ ; the Native Christians were inmates of a Convent. So that all were especially liable to come under notice and of nearly all it may be said that they were living under conditions very different to those obtaining among the mass of the people. Seven of the number were certainly meat-eaters, and probably if the truth were known in this respect as regards the Hindus and Brahmins, the number of those who indulged in meat would be higher ; but without pressing this point, the undoubted meat-eaters in the series form a much larger proportion than would be found in the population at large in that part of India. We have also to consider the fact that these patients were nearly all subject to the influences of "urbanization," the worst characteristics of which are nowhere more developed than in Bombay and Poona ; and the students (5 in number), the policemen (2) and the clerk, (making more than half the total of Brahmins and Hindus concerned) were in all probability new to these influences, among which may be included contact with Europeans. Similar remarks are applicable to Rogers' series which is made up of 13 cases occurring in Hospital practice in Calcutta, there being 5 Native Christians, 5 Hindus and 4 Muhammadans, the ages varying from 8 to 35 years. It is pointed out that Native Christians are far more readily brought to hospital than the other classes, but the proportion of Muhammadans to Hindus in the series is very high, considering that the former stand to the latter in the ratio of 1 to over 2 in the general population of the city ; moreover, the caste and diet of the Hindus is not stated. Rogers adds a note of seven cases of continued Fever clinically resembling Enteric, among members of a high caste Hindu family, and in two of which hæmorrhage from the bowels occurred ; the blood of one case submitted to the serum reaction gave a positive result, in a dilution of $\frac{1}{100}$. The case-mortality observed in this series of Rogers was 30 *per cent,* and from the detailed description of symptoms the cases were typical of the disease as met with in Europeans, being no less severe and no less well-marked in all the classical features.

Now this is at once striking and important ; the question arises as to why qualified observers elsewhere have found such difficulty in the recognition of the disease with which they are well-acquainted both in theory and practice, and which there is almost a sporting impulse to hunt down : the prevalence of Enteric Fever among Natives is one of the first problems which every medical officer is incited to solve. The explanation is probably to be sought in the hint given by Colonel Crombie when he was led to designate these cases under the term "urban fever" ; it is not contended that Enteric or paratyphoid fever is never to be found outside the large urban centres, for this is certainly not the case ; but so far as the available evidence leads us, it is clear that the conditions of the new civilization which has been imposed upon the country and upon certain classes of the population, cannot be ignored in appraising the facts and their etiological significance. It is impossible that a well-defined disease with which every medical man is more or less familiar, and which causes death in 30 *per cent* of the cases, should be overlooked under a scrutiny which has extended in ever-increasing vigilance over a quarter of a century. The records of the fever mortality among the large bodies of Native troops and prisoners can leave no possible doubt on this point ; for we can certainly not take refuge in the assumption that these bodies are protected from attack by reason of their age-constitution, seeing that the majority of the cases authenticated by the methods employed by Lamb and Rogers are included in the 18 to 30 age-period which prescribes the range for service in the Native army and in which 40 *per cent* of the prisoners are included ; and then, again, there is the striking identity in the rates from Enteric and other fevers in the two classes of the community over a very long series of years to be accounted for. It is, therefore, difficult to subscribe to the assumption that Enteric fever is a common and prevalent disease of the Natives of India at large, nor ought we to apply the results obtained in certain large urban centres, to which large numbers of the rural population have been attracted during the last century, to the mass of the people. And, moreover, we are justified in awaiting an even more cogent demonstration of the true etiology of these urban cases than is afforded by the serum reaction even in capable hands ; it is at least strange, in the light of Row's work in Bombay, that no case of paratyphoid was detected in the considerable series of 34 cases. What we must recognize, at this stage, is a relatively small amount of Enteric (or paratyphoid) fever among individuals drawn from their natural habitat to be subjected to a civilization to which they are not adapted, with all the alteration in the conditions of life thereby involved, and that the liability to the disease appears to fall in a direct ratio to the force of the sum of these factors ; a careful consideration of the epidemiological facts already set forth can only lead to this conclusion. Any reference to the recorded high mortality from "fevers" among the general population is beside the mark ; neither the selected and most robust, nor the feeblest and most decrepit classes die of fevers (the combined rate is now under 2 *per mille*) when under medical control, which it is impossible to credit with the prevention of Enteric Fever in any notable measure, when it is comparatively ineffective against infections of a like nature; for this medical and sanitary control has to deal with a large and constant flow of individuals coming from the body of the population living under their natural, insanitary conditions, with constant risk of introduction of infection in whatsoever forms it takes.

We have next to show the local distribution of Enteric Fever among the prisoners which is of interest in exhibiting a departure in some essential respects from that already discussed in the case of the Native army, but which may be discounted to some extent by the evidence afforded by the *post-mortem* examinations.

Enteric and Remittent Fevers among the Prisoners. Local distribution by Provinces. Mean ratios per mille, 1895-1904.

Province.	Aggregate Strengths.	Enteric Fever.		Remittent Fever.	
		A.	D.	A.	D.
Madras... ...	91,683 ...	·9	·32	1·6	·15
Central Provinces ...	48,268 ...	·8	·33	4·4	·87
Burma	125,555 ...	·4	·22	9·2	·43
Punjab	132,986 ...	·4	·15	3·3	·52
Bombay	86,780 ...	·3	·13	11·4	1·69
Bengal	184,761 ...	·3	·10	6·7	·71
United Provinces of Agra and Oudh.	296,042 ...	·2	·08	4·8	·32
Assam	12,581 ...	·2	·08	8·8	1·91
INDIA* ...		·4	·15	5·9	·61

There are striking differences between this record and that for the Native Army already given, but still we find no definite relation, direct or inverse, between the incidence of the two fevers that are most likely to be confounded diagnostically. In view of the previous discussion it will save the reader's time and patience if we confine our remarks to the case of Madras in which the contrast with the local distribution

* Excluding the Convict Settlements in the Andamans from which no cases of Enteric Fever have been reported.

among the Native Troops is most remarkable, for the rate in the Central Provinces for the latter body was shown to be relatively high, though less than that in the true continental area. To what then is the striking pre-eminence of Madras due in the case of the prisoners ? To this the reply must be in the first place that the available evidence points to erroneous, or at least questionable, diagnosis on the part of two or three medical officers; at the same time it must be allowed that this is only one factor, for we shall see that there is reason to believe that the area from which these returns come (W. Coast), is altogether remarkable as constituting the one locality in which the disease may be said to be endemic among the Natives. During the ten years in question there were altogether 87 cases and 29 deaths reported from the Madras jails of which a little more than one half, *viz.*, 45 and 15, respectively, were reported from three institutions in only three years of the decade under review, *viz.*, 1897, 1900 and 1904, and a careful perusal of the *post-mortem* reports reveals a lack of appreciation of the significance of the evidence which is detailed fully and conscientiously ;—the effects of Dysentery, Tuberculosis and Entozoa and, possibly, of the disease caused by the Leishman-Donovan body are apparently confounded with those produced by Enteric Fever, and at the same time many cases returned as dying from Remittent Fever have presented all the signs of Pneumonia or Dysentery. The fact of ulceration of the small intestine has been held to justify a diagnosis of Enteric apart from the character of the ulceration and in disregard of the fact that ulceration of the ileum is a not infrequent result of chronic Dysentery, of Tuberculosis, of malaria and possibly of the action of the Leishman-Donovan body so prevalent in Madras. The following extracts will convey an idea of the facts on which the diagnosis of Enteric Fever has been based :—

> "Mesenteric glands enormously enlarged and softened. Numerous gangrenous oval ulcers corresponding to Peyer's patches, and small circular ulcers in the Ileum. The cæcum and appendix gangrenous; the large intestine contains a large number of circular ulcers." * * "Several ulcers found at the Ileo-cæcal valve and about 2 feet above it, the mucous membrane congested and ulcerated here and there. Large intestines and sigmoid distended with gas and fæces." * * "Three circular ulcers in the ascending colon, gangrenous ulceration of the cæcum and several oval and circular ulcers in the ileum with perforation just above the cæcum. Spleen, 28 ozs." * * "Several gangrenous ulcers found in lower part of ileum; ascending colon also congested" * * Along with the ordinary signs of acute croupous pneumonia, "the large bowel had ulcerated patches along its course, and a circle of ulcers round

the rectum; a considerable patch of irregular ulceration a few inches above ileo-cæcal valve." All the above cases were furnished by one jail in 1904. Again; "there are several ulcers varying in size form a split pea to a three-penny piece over Peyer's patches; in the cæcal pouch an enormous mass of ulceration formed by the coalescence of several large ulcers in process of sloughing; the calibre of the lower part of descending colon is much constricted, amounting almost to stricture; mucous membrane of rectum has several patches of intense congestion." * * * "The intestines, large and small, had patches of congestion, and some of these were ulcerated; there were too many ulcerated patches in the large intestine to note exactly the position of each; a perforation of the ileum (which was cartilaginous in texture) just below (*sic*) the cæcal valve." * * * "The case commenced with dysentery but terminated fatally from Enteric Fever; there were ulcers throughout the large and small intestines, also signs of perforation." * * * "Ulcers were found in the intestines." * * * "These cases were diagnosed by the clinical symptoms, *e.g.*, *passage of sloughs*, &c." * * * "Admitted for Typho-malarial fever; severe diarrhœa set in, motions at times containing slime and blood. Passed 16 worms after a dose of Santonin on admission. *P.-M.*—Small intestine in the lower part of ileum presented ulcers of various sizes, some superficial, others deep, and covered with dirty-looking slough. One small ulcer found in cæcum. Rectum prolapsed and inflamed and hypertrophied, as was also the sigmoid flexure." * * * "Admitted for dysentery, and motions changed to diarrhœa. *P.-M.*—Throughout the whole length of the ileum ulcers of various sizes with indurated bases and covered with slough. * * * A few ulcers were found in the large intestine, with cicatrization of ulceration in descending colon and rectum." * * * "Mesenteric glands greatly enlarged; mucous membrane congested throughout. There are small single ulcers here and there throughout the length of the large bowel, about ¼ inch broad and circular. About the ileo-cæcal valve there are recent ulcers covered with yellow slough. There are only one or two ulcers in the lower half of the ileum, circular and not running longitudinally. A few ulcers also found in the jejunum. Spleen 8¼ oz. Normal." * * * "Right lung and right kidney much congested. * * * In the ascending colon about 12 ins. from the cæcum the mucous membrane congested, and here there were three ulcers, oval in shape, deep and covered with greyish slough. Many similar ulcers were found in the cæcum, and here and there in the ileum. No perforation and no worms found." * * * "*Antemortem* clot in heart. A patch of congestion over large curvature of stomach. The mucous membrane of the ileum presents signs of the acute catarrah with a circular patch of ulceration 1½ ins. in diameter, 6 ins. above the cæcal valve; the margin of this ulcer is elevated and the surface irregular. Mesenteric glands all enlarged. Large intestine normal. Spleen, 7oz. * * * "Small intestine; general attenuated condition of the coats most marked in jejunum and ileum; upper part of duodenum deeply congested; several erosions and superficial ulcers found in lower half of duodenum and jejunum varying in size from ¼—1 inch diameter, in the long axis and parallel to long axis of intestine. Edges of ulcers thin and ragged and not raised. Large intestine: patches of congestion present, more marked in cæcum and rectum. No parasites. No ulcers."

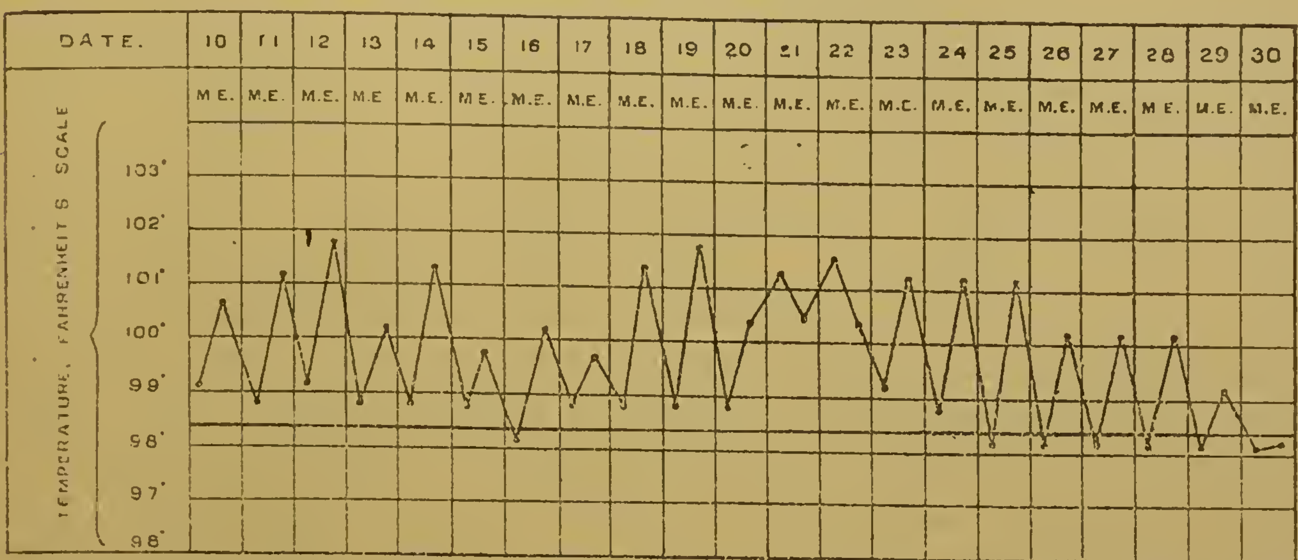
The reports on several fatal cases of "Remittent fever," which need not be quoted, give clear evidence of acute pneumonia or dysentery, and in one case pyelitis, but in no instance was there typical ulceration of the small intestine. In connexion with the foregoing extracts from the *post-mortem* records of "Enteric Fever," it may be remarked that in the case of one jail which returned 11 cases and 5 deaths out of a total for the whole province of 13 and 6 respectively (in 1900), it is noted in the Sanitary report that "the sickness and mortality were owing to the semi-starvation of the majority of the prisoners before admission, due to scarcity prevailing in the Hill tracts." Now it is just in such conditions that we find fatal dysentery prevailing among the famished people, as a study of the pathology of the chief cause of death in times of famine by Drs. Lewis and Cunningham has shown (see Annual Report, Sanitary Commissioner, India, for 1877). It is far from our contention and that in none of these cases was true Enteric infection in operation; the object of the quotations from the *post-mortem* reports is to show the grounds on which diagnosis has been commonly based in a few of the Madras jails which are, and have always been, the main sources of the exceptionally high prevalence of the disease as recorded in that area; that the results of true *typhosus*—and more probably of paratyphoid—infection may herein be exhibited may be granted, but the fact could scarcely be established on the evidence forthcoming. Major Fearnside, I.M.S., a capable observer, who has devoted himself specially to the pathology of jail diseases by *post-mortem* research and who has been in charge of large jails in the Madras Presidency for thirteen years, informs the writer that he has only met with five cases of Enteric Fever in the course of his experience; and that not one of these was fatal. He raises the pertinent question as to how far the disease associated with the Leishman-Donovan bodies may give rise to symptoms simulating Enteric Fever, and thus account for the failure of the serum reaction (Widal) in a large proportion of cases which are clinically regarded as true Enteric. In a very careful review of the sickness and mortality in some of the Madras jails he has pointed out that in 293 necropsies performed in the decade, 1887-96, Tubercle of the lung was found in 61 cases and ulceration of the bowels in 116, *i.e.*, in about 40 *per cent* of the whole. In the absence of the knowledge of the prevalence of the Leishman-Donovan disease when his paper was written (1898), he attributed this frequent ulceration to dysentery, malarial cachexia or to tubercle, in the great majority of cases.

Major Fearnside was formerly personally in control of one of the three jails in which the recent records of Enteric Fever have been high, and he has published in the *Indian Medical Gazette* (April, 1904) some suggestive remarks on the influence of intestinal entozoa in raising the mortality in some of the Madras jails and on the notable effect of anthelmintics in reducing the high death-rates from bowel diseases: dysentery, diarrhœa and catarrhal enteritis. For example, the mortality from bowel diseases during the three years, 1891-3, ranged in one jail (subject in the records to "'Enteric Fever'') from 33 to 49 *per mille* of the average strength ; then with the recognition of the part played by entozoa and the introduction of the treatment by anthelmintics, the death-rate from these disorders fell in 1894 to 10·9, in 1895 to 9·7 and in 1896 to 1·5 *per mille.** His record shows that in one year no less than 2,703 worms, chiefly *ascaris lumbricoides*, were obtained from 255 patients, the prevalence of the round worm being favoured by the moist damp coast climate and by the opportunities afforded, by the habits of the people, for infection and reinfection. Dealing with the symptoms due to the presence of these parasites he refers to headache, faintness, malaise and dyspepsia with abdominal fulness in the first stage, followed by muco-enteritis, vomiting and persistent diarrhœa ; the temperature rising to 102° at night with a remission of a degree in the morning. The stools contain much jelly-like mucus, and the conditions may persist for long after the evacuation of the larger worms. The fever may last for weeks and "*simulate exactly enteric fever* ; and not only this, but the *post-mortem* appearances are often similar. Pain in the right iliac region is marked (the cæcum being a favourite nidus for the worms) and one not cognizant of the prevalence of *A. lumbricoides* might mistake the whole disease for enteric.'' Temperature charts are given which fully confirm this statement, and one of these is appended. Finally, a definite dysenteric condition is set up by the continued irritation maintained near the ileo-cæcal valve and the constant passage of mucus and pus, the fever continuing and assuming a more hectic type. Major Fearnside refers the general symptoms, fever, headache, nausea and depression to the toxin excreted by the worms which is probably rendered effective by the enteritis induced by their presence in large numbers. The young nematode bores into the mucous membrane and sets up local inflammation, which often goes on to ulceration, gangrene and emphysema and,

* Similar results have been achieved elsewhere, *Indian Medical Gazette*, July, 1905.

occasionally, to perforation. Cases are quoted which show the destructive effect on the intestinal walls as found on autopsy, one of which was returned as "Simple Continued Fever;"

CHART No. XXIV.



Enteritis caused by *Ascaris Lumbricoides* (Major Fearnside, I.M.S., *Indian Medical Gazette*, April 1904.)

the *post-mortem* disclosed the intestine with thickened coats and superficial ulceration of the ileum, eight ascarides being found in the small intestine. (See also Prof. Blanchard in *Archives de Parasitologie*, t.x., No. 1.) These considerations should be borne in mind and we shall deal later with the evidence of the more or less endemic prevalence of Enteric in this area.

To take one or two examples at random of the *post-mortem* results recorded in jails in Bengal; during the last twelve years (1893-1904), it will be found that out of a total of 180 deaths occurring in the Hughli jail, 154 were submitted to autopsy, but in no case was Enteric Fever diagnosed. There are several examples of well marked and typical dysenteric lesions in which ulceration extended to the ileum, and there were cases of tubercular ulceration of this part of the intestine. There are only two cases examined and reported on by Assistant-Surgeons in the absence of the Superintending Medical Officer (I.M.S.) which might possibly be regarded as of an Enteric nature; one in which "the small intestines presented patches of ulceration. Peyer's patches slightly enlarged"; (no mention of large intestine) and which was returned as "death due to chronic diarrhœa" —duration of illness, one week; the second died after two days' illness from peritonitis due to "a perforation the size of a split pea, about three feet above the ileo-cæcal valve; there were also two small ulcers, size of a pin's head, 3 ins. above the perforation.'' Lt.-Colonel Crawford, I.M.S., who sends me these *post-mortem* records, says: "I must have done at least 1,000 autopsies in the jails and in medico-legal cases, and I do not remember ever seeing Enteric lesions save in one case in the Calcutta College Hospital. In medico-legal cases one is not specially looking for these lesions, and many of the bodies are too decomposed to see them even if present." Making all due allowance on this account, the statement is sufficiently remarkable when it is confirmed so abundantly in the experience of the great majority of officers in medical charge of jails, and in view of the statistical and other evidence we have adduced. During the last 20 years out of a total of 154 deaths occurring in the Cuttack jail only six were returned under the head of fevers, of which four were classed as "Remittent." The *post-mortem* records show that one was due to double pleurisy; in two, no intestinal ulceration was discovered, and in the fourth there were dysenteric ulcers in the large bowel with a few ulcers in the cæcum and ileum. This long digression should not be valueless in elucidating the main problem as a complement to the most recent views based on the results of the serum test.

We must devote the remaining space at disposal to a brief review of the facts and opinions derived from experience of hospital and other practice among the general civil population. It must suffice to quote some of the most definite points elicited in the replies to numerous enquiries; at the same time it will be clear to the reader that the record is, by its nature, both incomplete and inconclusive, and that it affords no valid basis for a comparison with that for the Europeans.

PUNJAB.—The Professor of Medicine at the Medical College, Lahore, has kindly furnished the following statement of cases treated at the Mayo Hospital for the last five years 1900-4:

	No. of European patients.	No. of Eurasian patients.	No. of Native patients.	Enteric among Europeans.	Enteric among Eurasians.	Enteric among Natives.
1900	260	143	3,387	9	...	3
1901	197	191	3,483	5	1	3
1902	198	141	3,669	8	1	1
1903 ...	176	182	3,510	6	...	6
1904	174	134	3,427	4	...	...
	1,005	791	17,476	32	2	13

We have already seen that during the previous six years ending 1899 there had been 11 cases among Natives, reported by Colonel Browne, *i.e.*, therefore, a total of 24 cases recognized in this large college hospital in 11 years.

Major Sutherland adds that generalizing from his experience, Enteric Fever is very rare among Natives and that when it occurs there is usually some departure from the usual habits of life. "I imagine it to be phenomenally rare among pure vegetarians and that meat-eaters are more subject to attack, but I would not dogmatize from this impression. To the best of my recollection I have never seen a case of Remittent Fever in the Mayo Hospital which, if it failed to show malarial parasites or to yield to quinine, or failed to react to a culture of the Malta fever coccus, did not prove, while under observation, to be due to tuberculosis or other pulmonary affection, or to syphilis or some pyogenic infection." He further holds the opinion that a considerable proportion of cases returned as Enteric Fever should properly be included in the paratyphoid class. "The procedure adopted in all cases of fever is to look carefully for signs of local infection first, and it is astonishing how often it is to be found,—perhaps a bronchial catarrh, a patch of broncho-pneumonia, an adenitis of the mesenteric glands, a bile infection, a urinary infection, and so on. Having found a local trouble, the sputum, urine, etc., is examined microscopically to find the infecting micro-organism, and when found, it is returned as pneumococcal infection (bronchial catarrh, broncho-pneumonia, pyelitis, etc.), and tubercle infections, streptococcal infections and others are returned in the same way. If need be, we make splenic or lumbar puncture for help.

"When there are no local signs we look on the case as possibly malarial, and make a blood film and do a differential leucocyte count. If malarial parasites are found, the case is returned as Malaria, in one or other form depending on the form of parasite found and on the type of fever assumed; and Relapsing fever would go under its own heading in the same way, though it is a very rare fever with us. Should nothing be found in the films, the differential counts may point to malaria infection, pyogenic infection, worm infection, etc., depending on how the mono-nuclears, poly-morphonuclears, eosinophiles, &c., are affected, and we return a fever with mono-nuclear increase which yields to quinine, as malaria, according to the type of fever assumed. If this examination is also negative, and the fever does not subside under 30 grains of quinine daily in a few days, the serum test generally gives positive results, and may show the case to be either Enteric or Malta fever, when it is returned as such. In my experience very few fevers are left over in the end which have to be returned in an uncertain way, like Simple continued Fever, Remittent Fever, Febricula, etc., though I dare say some febriculas get returned as malaria."

It will be allowed that this stringent scientific method of diagnosis renders the evidence in regard to the non-prevalence of Enteric Fever very forcible.

The reports of several Civil Surgeons (I.M.S.) of the largest experience coincide as to the main fact of the rarity of the disease in their experience, but we shall merely quote the remarks of two officers whose status and qualifications are guaranteed by the fact that they have held the important post of Civil Surgeon at Simla. One writes: "My opinion is that Enteric is not nearly as common in the Natives as has recently been believed. I have been constantly on the look-out for it and have sent blood for examination to the Pasteur Institute in every case in which I had the smallest suspicion that the disease was present. During the past three years I have seen four cases (one Eurasian), the diagnosis being confirmed by the serum test." All were meat-eaters. "Native Assistant Surgeons tell me they meet with cases frequently, but I am doubtful of the diagnosis, for these are just the cases in which the Civil Surgeon would be called in for consultation." The other says: "In my opinion Enteric Fever is very rare in Natives; I have not had more than one dozen cases in my career. In 307 consecutive autopsies as Police Surgeon, Calcutta, there was no case of Enteric ulceration nor of perforation due to enteric ulcers. During 14 years, I have always myself made all the *post-mortems* in jails and have not yet seen typhoid ulcers in a Native."

The writer has been kindly favoured by Dr. Browne, of the Church Missionary Society, with reports from 13 Medical Mission Stations all in charge of highly qualified officers, the results from the stations being omitted where the Missionaries are medically "unqualified." The reports deal generally with the practice of the year 1904 in which about 360,000 patients were under treatment, and among these, 10 cases of Enteric fever were diagnosed. Dr Lankester, Peshawar, while stating that no case occurred among 700 in-patients in 1904, says: "I have had from time to time cases of Enteric among Natives as to which the diagnosis was quite clear, but the disease among them is so very rare that one perhaps naturally hesitates to pronounce a positive diagnosis until the symptoms are quite unmistakeable." Another writes: "Personally I have found it very rare. I have had only two really authentic cases under my own care during my 4 years' experience here." (These cases are included in the total of 10 referred to.) A third says: "No Enteric cases came to us at all this year; in fact we rarely see it among Natives." A fourth believes that "many cases of continued fever with diarrhœa are really typhoid especially amongst children, but personally I have never had a case long enough under observation to make a positive diagnosis." A fifth writes: "I consider typhoid very rare among the Natives; during this last year, we had one typical case in a Brahmin girl, 5 years of age. There were 766 in-patients and 10,023 out-patients; the diagnosis of the latter is of course very uncertain." Miss Church (M.B., Lond.) says: "I have had very few cases under my care; I can only recall one in Lahore,—a Native Christian, aged 14. During the 5 years I had charge of the Scotch Mission Hospital in Madras I think I had one case. During 2 years in Calcutta I had none, but the number of patients was small." Dr. Neve of Srinagar, Kashmir, reports 4 or 5 cases during the year, the number of new patients treated being 16,000 to 17,000. "The disease is not common among Natives; perhaps as quite young children they get it in the form of an obscure fever. I suspect that as against Enteric the tissue resistance is higher." Another writes: "Our new patients numbered 13,201, old cases 25,528; maternity cases, 1,826; visits to houses, 2,733. Judging from the experience of a good many years: "I should say Enteric is rare among non-Christian Native women and children. I have seen typical and undoubted cases in previous years only in Christians." Lastly, it is said by a doctor on the North-West Frontier: "I feel sure that Enteric is not at all uncommon among the native population, but as we hardly ever get *post-mortems* and are unable to do Widal's test, doubtful cases come to be entered as continued or Malarial fever." Another from the same locality writes in similar terms, though no cases were recognized from the end of 1903 to the beginning of 1905.

Dr. Martyn Clark, of Amritsar, whose experience in medical mission work is quite exceptionally great and valuable, informs the writer that, in his opinion, Enteric Fever is commoner among the Natives than formerly, though this may be only an apparent phenomenon due to better diagnosis and to the greater confidence of the people in British medicine. But for all that, he is inclined to view the result as largely the effect of a change in the habits of the people in the direction of more Western modes of life involving increased liability to new diseases—" a disease of modern introduction which is establishing a foot-hold among the Natives." " As regards Natives I should call the disease neither rare nor prevalent, but increasingly appreciable. It is nothing like the scourge it is among the European population, but without being prevalent, it is there ; middle age, early manhood and adolescence are the periods of liability. It occurs equally in urban centres and in villages. It is in no way connected with meat-eating, but rather with milk, and I presume water. It is never epidemic, but always sporadic, an observation I cannot account for. I should not call it prevalent among children any more than among adults,—certainly not so as to confer immunity in later life. I am distinctly of opinion that it exists among Natives in nothing like the amount to account for the alleged infection of European troops in bazaars and Native towns. In towns, it is remarkable to think of the filth, smells and general sanitary vileness, and then to realize the non-prevalence of the disease."

The experience gained in medical mission work is especially valuable as it brings the doctor into very intimate relations with the people, and it has therefore been quoted at length.

CENTRAL INDIA.—The Administrative Medical Officer, Central India, informs the writer that he has met with "several cases of Enteric which were corroborated by Widal's test," but he holds that not all Remittent fevers that give a positive reaction are to be classed as Enteric. " There are many Remittents, not Malarial and not Enteric, which, in many cases I have proved to be Malta fever and which gave the Widal reaction." Malta fever is much more prevalent than is commonly supposed (see reference to recent work of Major Lamb).

A senior officer of great experience of medical work in the Rajputana States makes the following interesting remarks :—

"In 1901 I went to Ajmer, and on looking up the mortality statistics of the Ajmer City I noted that 700 cases of Enteric had occurred during the previous year. This rather staggered me, and I at once instituted enquiries as to localities in which it had been prevalent,—the conditions of sanitation, water-supply, etc.,—and could get no information of any value. No steps seem to have been taken in these directions and I found that there were no special localities to which the disease could be traced, but simply that *all cases of fever lasting over a certain time* were entered as 'typhoid.' I further elicited that there had been a few cases of Enteric, but these had been either in Eurasians or Europeans. Natives suffering from prolonged fever were simply put down as Enteric cases, but no special care seems to have been taken in diagnosis, etc. I then gave orders that *every case* at all simulating 'Typhoid' should be at once reported to me for my personal investigation, and this order I repeated at intervals, but I never saw a single case in a Native during the year I was there." He goes on to refer to a form of Remittent fever ("Motijara") having some of the characteristics of Malta fever: this would seem to present a promising field for research, as it is frequently referred to in the Reports received. The Civil Surgeon of Ajmer, the incumbent at a later date, is strongly of opinion that whatever be the case with "Motijara," many of the cases of Remittent fever in

Native and Eurasian children, often accompanied by obscure abdominal symptoms, are of an enteric nature,—and that to this the immunity of adults is due. Further he furnishes a list of nine cases of Enteric Fever, one of which, in a sepoy, is doubtful, as the *post-mortem* showed acute hepatization of one lung, "slight congestion of Peyer's patches ; no ulceration." The other eight cases occurred among young Rajput chiefs and nobles while at the Mayo College (ages 13 to 18), and three of which were under his care. These cases occurred between 1895 and 1904 inclusive (three in December 1895) ; all recovered, and one, the last, case was confirmed by the Widal test. All but two of the total (9) were meat-eaters. It should be added that the total number of boys at the College during the 10 years in question was 189, which gives a very high attack rate, but the three cases in December 1895 would appear to have had a common simultaneous origin as there were only 10 days between the admission of the first and the third. It need scarcely be pointed out that these young Chiefs observe in many respects (especially as regards diet) European or semi-European customs ; there can be little doubt, so far as clinical symptoms afford a guide, that most, if not all, of these were true cases of Enteric Fever.

Reference may be made at this point to the experience of the well-known Muhammadan Anglo-Oriental College at Aligarh, of which the writer was in medical charge for about seven years (1891-7), during which period no case of Enteric Fever occurred. The following is a statement for the last four years :

Muhammadan Anglo-Oriental College.

YEAR.	Average number of pupils.	Total cases treated, All Causes.	Cases of Remittent Fever.	Cases of Simple Continued Fever.	Cases of Enteric Fever.
1901	415	2,819	30	21	......
1902	496	3,048	21	15	......
1903	531	3,596	15	21	.....
1904	521	4,538	5	16	1
	1,963	14,001	71	73	1 (recovered.)

Note : Boys are not removed from College when ill, but they are sometimes sent home for change after recovery. No one is known to have died at home after illness contracted at the College. There were only two deaths from all causes, one from dysentery and one from cholera, during the four years. The boys have access to a large native town (population 80,000), but the College is well situated in the civil station.

If Enteric Fever were prevalent among Natives we should surely have evidence of it in this admirably conducted Institution to which boys come from all parts of India, with constantly recurring risk of importation every term.

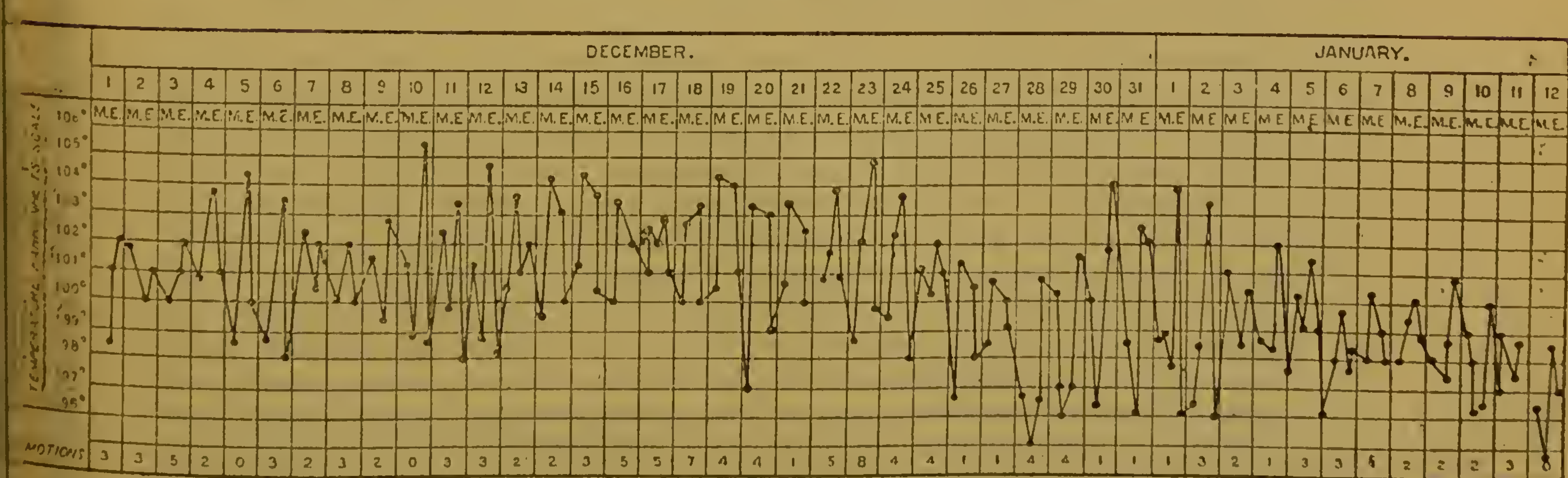
The Civil Surgeon of Agra, one of the largest charges in India, says : "My opinion is that Enteric Fever is very rare among Natives. I see a great many patients in private practice ; cases of Continued fever generally turn out to be tubercular or malarial. I do not think I have seen a single genuine case in jail or police hospital practice.'

The Residency Surgeon at Hyderabad has kindly furnished a report of cases observed in the Chudderghaut and Secunderabad suburbs, showing that 56 cases are on record as occurring during the last 10 or 12 years; of these 5 were in Europeans, 18 in Eurasians and 33 in Natives. Chudderghaut, where 46 of the total number occurred, is near Bolarum, the European cantonment, and it is said that in many cases the infection may have been contracted there, as visits to the cantonment are frequent; but the British soldier rarely visits Chudderghaut, and outbreaks of the disease in the barracks cannot well be ascribed to infection in the civil suburb.

MADRAS—The acting first Physician at the General Hospital, Madras city, informs me that during the past 5 years 177 Europeans and 24 Natives have altogether been treated in his wards for Enteric, about 700 Europeans and between 300 and 400 Natives being admitted annually for all causes. Of course, as has already been pointed out, Enteric Fever among Europeans is far more likely to come under observation than that among Natives. It is said: "One not seldom sees forms of fever, Continued, Remittent or undulant, among Natives which are not malarial and do not conform to the Enteric or paratyphoid type, but which may yet be due to some gastro-intestinal infective process."

The Second Physician, Major Donovan, whose researches in connexion with the Leishman-Donovan body are now well known, "considers the disease rare in Madras City and surroundings; in my wards at the General Hospital during 1903 and 1904 among a total number of 2,500 patients treated, only 5 cases of Enteric were admitted. But in a three years' experience in S. Canara (West Coast) especially of the town of Mangalore, I found Typhoid decidedly common among Natives at certain times of the year. I have been much struck by the close resemblance to Typhoid of what I have called "Human Piroplasmosis" (due to Leishman-Donovan bodies); the pyrexia has closely simulated that of Typhoid, and moreover Widal's reaction has been found positive in a 1 to 20 dilution." A chart appended will illustrate the point as to temperature, and the *post-mortem* records of fatal cases (Madras General Hospital Report, 1903) refer to the intestinal lesions in this disease, which might well be confounded with those of Enteric fever by a casual and inexperienced observer.

CHART No. XXV.



"Piroplasmosis" (Leishman-Donovan.)

Major Donovan's reference to the prevalence of Enteric Fever on the West Coast of the Presidency lends interest to reports from S. Canara and Malabar, kindly furnished by the District Medical Officers. Of the former it is said that the disease is undoubtedly present and is observed chiefly among the middle and upper classes, and that it prevails mostly in the large town of Mangalore situated on the coast. Cases are rare in the villages. The disease appears to be increasing and is most prevalent in the very rainy months of June to September or October, though it also occurs at times in December and January. Native Christians appear to be most liable and at the age of 14 to 30. The disease is attributed to the deposit of fæcal matter and refuse on the soil of the compounds of the homesteads (where also corpses are interred) and the organic matter, under the influence of an enormous rainfall, is washed into the shallow wells, the water-level of which is so high that the housewives can dip their receptacles into the water by hand. Each family has its own shallow well, quite unprotected, and close to the dwelling; the conservancy arrangements are *nil*, save in respect to the services of the pigs which act as scavengers; the disease is observed to cling to certain houses, and no precautionary measures are taken on the occurrence of a case.

The Medical Officer of Malabar furnishes similar but more detailed testimony, and we need only note the points not dealt with in the Canara report. "In the chief town, Calicut (population 76,000), I should say that 20 to 30 cases come under my direct observation every year, but there are undoubtedly a very much greater number in the town who never seek European advice. Some of the cases are very typical, and the diagnosis has been verified by the Widal reaction, and by the discovery of *b. typhosus* in the urine." House epidemics have been noticed. As regards the water-supply and the absence of conservancy the details given are similar to those prevailing in S. Canara. Entozoa are very common indeed, including ankylostoma; catarrhal inflammation of the bowels, as also dysentery and diarrhœa are very rife.

Further inland, where the wells are deeper and fewer and, being common property, are far better conserved, bowel diseases (including Enteric) are certainly far less prevalent.

To this account may be added some remarks by the Sanitary Commissioner of the Madras Presidency, Colonel King, C.I.E., I.M.S., who had a large experience of the disease before entering the service and who has always taken the greatest interest in the subject of its occurrence in this country. After giving instances within his own knowledge, he sums up: "that whilst Typhoid exists among Natives, it is not common in this Presidency and is not a disease of rural tracts but, where it occurs, of towns." He then proceeds to distinguish between the prevalence on the East and West coasts (the whole area being practically seaboard) based on the geographical and physical contrasts, and on differences in the habits of the people: "whilst on the East coast typhoid amongst natives exists but is very rare, on the West coast, it is, though not proved to be a pressing cause of mortality, frequently recognized." * * * "On the East Coast the soil varies greatly (from 'black cotton,' to laterite, with shallow sub-soil of shales and traps, to alluvial delta land) and the rainfall amounts to an average of 46 inches. Although there is lack of conservancy of the water-supplies, gross, direct and continuous defilement is rare. On the West Coast, there is an abrupt contrast; the soil is largely a loose lateritious gravel with a substratum of clay favouring shallow wells; and quite near the sea, the upper soil is mere sand. The rainfall amounts to 133 inches, and frequently 10 inches fall in one day, so that the probability of transfer to the wells of matters on the surface and *viâ* the rapidly fluctuating ground-water is obvious. * * * Each house stands on its own separate and considerable area of private enclosed ground, so that a village proper may extend to ten to twelve miles, and yet may not contain more than eight or nine thousand people. The consequences of this arrangement are that the compounds (or "parambas" as they are called) are the great dumping ground of all effete matter. For night-soil purposes a shallow pit is dug in the soil, when the compound is small. Over this two planks are placed, and when the pit is full it is filled up. This goes on year after year. In the larger parambas, defæcation proceeds on the soil surface, but chiefly in corners specially devoted to this purpose. The rate at which nitrification proceeds is astonishingly quick, so that what was a mass of fæcal matter becomes unrecognizable from soil within 48 hours of deposit. In non-municipal areas, children are universally buried in the parambas and adults burned or buried as their caste allows. Practically, each paramba has its own water-supply. In the good class of houses, there is a bathing tank besides the usual shallow well which, if possible, immediately adjoins the house, so that the housewife may draw water direct from her window without going into the eternal rain. "The Muhammedans or Moplahs of the West Coast afford in their habits a complete contrast to the Hindus. They are dirty in their persons, live in very over-crowded houses, and do not luxuriate in bathing. They live side by side with their dead. The houses are built round mosques and each mosque compound is an over-crowded graveyard. Fæcal cesspools or shallow pits are also employed for at least the use of females in poor and crowded houses, although removal is practised amongst the better classes. Their water is almost exclusively drawn from wells in the neighbourhood of the churchyards. My theory is that under East Coast conditions fæcal matter reaches water after it has had considerable time under favourable conditions to favour the multiplication of non-pathogenic microbes at the expense of the pathogenic; whereas on the West Coast, year by year, there is risk of a more gross contamination by fæcal matter in a less perfect condition of change; and, moreover, there are the disadvantages, if once a "paramba" is contaminated by typhoid matter, of the continuance of its transmission. On this very theory when last on the West Coast, I made certain enquiries which pointed to the fact that only exceptional houses get attacked, and that, time after time, various members of the family disappear, under the influence of a disease that from its history *might* be typhoid." * * * "I would state that of the two East Coast towns where typhoid is known, Madras City, although it has a public water-supply (itself open to possible contamination) nevertheless largely uses shallow wells, which are side by side in every house with its latrines; (this language must be regarded as "general" and applicable to certain classes of native houses only). Now as to Nellore, it is the only town where I have seen water exposed to the risk of fresh fæcal contamination to a gross extent on the East Coast, and it is the only town, besides the large City of Madras, where typhoid amongst natives has been recognized." * * * "In the above, all attention is paid to water transmission, and nothing has been said of dust, flies, milk, etc. Of course, transmission by these modes is likely, but it takes little imagination to make the theory fit in also with these modes, having once arrived at conditions which point to the retention of vitality of the microbe."

It has been necessary to quote at length from this statement, not only on account of its intrinsic interest, but because we have in the West Coast of Madras an area which has the unenviable distinction of a reputation for Enteric Fever in the endemic form among the Natives; of no other part of India has this ever been suggested unless we except the recent statements of Rogers in regard to the great City of Calcutta. But then we must hold that the conditions of life of the people, both on the West Coast and in Calcutta and the largest cities, are quite exceptional, if in different ways. But after all, with our knowledge of the habits of the people in every part of India and the gross neglect of conservancy that prevails everywhere, we can scarcely expect to find an explanation of this peculiar local liability in the greater measure of sanitary neglect *per se*. In default of authentic data, it would be unprofitable to pursue the suggestions that occur to one in this connexion; we merely note that all competent to judge, including those officers now serving on the West Coast who have had ample experience in other parts of the Presidency, agree that the prevalence of Enteric Fever in Malabar and S. Canara is quite peculiar to those particular areas, so that the evidence, even if taken without qualification, does not impugn the consensus gathered from experience elsewhere. A glance at the Census Report for 1901, however, shows that the population of the West Coast areas is quite peculiar in its caste-constitution, and that though "Hindus" predominate here as elsewhere, the *castes* of these are special to the area.* We find the distribution given as follows:

	Hindus.	Musalmans.	Native Christians.
Malabar District	1,904,474	832,970	51,493
Calicut Town	42,744	30,158	4,007
S. Canara District	914,163	126,853	84,103
Mangalore Town	25,312	7,149	11,604
Madras Presidency	34.048,082	2,457,088	1,024,071

* See also "Imperial Gazetteer of India," Arts. "Malabar" and "Canara."

Now this statement reveals the fact that while Muhammadans and Native Christians together stand in the ratio of only 1 to 10 of the Hindus in the population of the Presidency, the ratio for S. Canara is as about 1 to 4, and for Malabar as nearly 1 to 2, or five times the proportion for the Presidency. But it is in the large towns that the disease is said to be most prevalent, and we see from the above table, that in Calicut, the Muhammadans and Christians amount to 80 *per cent* of the total of the Hindu population, in Mangalore to 74 *per cent.* Now nothing like this is to be found anywhere else in India save in the scattered hamlets of the extreme west of the Punjab, and we have taken no account of the low and other caste Hindus whose habits (and diet) are assimilated to those of the Muhammadans and Christians. It is notorious that pork is a favourite and frequent element in the dietary of the Christians and lowest castes in this area. Obesrvations in regard to race and caste habits in relation to the incidence of Enteric

Fever are required as a supplement to the peculiar physical conditions set forth by Colonel King with such picturesque force ; and then also we need confirmation of the etiological connexion of the *b. typhosus* with the disease regarded as Enteric, in view of the extracts quoted from *post-mortem* examinations in the Mangalore and Calicut jails, examinations which were not conducted by the Indian Medical Service officers who furnish these reports on the free civil population.

BOMBAY.—We have already referred to the work of Dr. Row (M.D., Lond.) in the elucidation from the bacteriological side of cases of an enteric type which are said to be frequently met with in the city of Bombay. Briefly, his results go to show the important rôle played by *b. coli* and *b. enteritidis* in the etiology of these attacks, only two cases out of 24 in nearly all respects clinically identical, being associated with pure *typhosus* infection.

The Professor of Medicine at the Grant Medical College has most kindly furnished figures of the cases among Natives treated in the Sir J. Jeejeebhoy Hospital during the last fifteen years, and with these are shown the facts as recorded for Europeans admitted into St. George's Hospital.

Enteric Fever. Bombay Hospital Returns.

	St. George's, Europeans.		J. J. Hospital, Natives.			Total cases all causes (medical), treated.
	Ad.	Died.	Ad.	Died.	Otherwise.	Natives.
1891	17	7	1	..	...	3,158
1892	26	6	2	2	...	3,154
1893	29	10	...	...	...	2,800
1894	38	11	3	1	...	3,015
1895	85	19	5	3	...	2,520
1896	39	14	6	3	...	2,565
1897	25	12	4	2	...	2,571
1898	33	9	1	...	...	2,822
1899	47	9	7	4	1	3,156
1900	61	3	8	3	2	3,144
1901	46	12	8	2	1	2,816
1902	60	24	7	5	...	2,528
1903	46	15	3	3	..	2,579
1904	45	7	17	6	3	2,611
Total 14 years ...	597	158	72	34	7	39,436

N. B.—Those discharged "otherwise" possibly went to swell the mortality.

The mean case-mortality *per cent* among the European patients is 26·4, a result almost identical with that obtained among the troops; that of the Natives (without including those discharged "otherwise") works out at 47 *per cent*. It is impossible to draw exact deductions from these figures for reasons previously stated, but the contrast is certainly remarkable as it stands; it will be noted however that the number of cases is much greater in the second half of the period in both cases, especially if the exceptional incidence on Europeans in 1895 be discounted. It is said that, as regards Natives, this is probably due to more exact diagnosis. Major Childe, I.M.S., thinks Enteric a common disease among Natives in Bombay and not rare, as has been stated, and that the well-to-do are more liable than the poor. He thinks the disease must have been confused with Malarial, Remittent and other fevers in the past, and this source of error still exists in less degree. He quotes an experienced Native Physician to the same effect, who in 1879 described three cases he had met with among Parsis. Major Childe has reported several cases met with in practice; in a series of ten, of which seven gave a positive reaction to Widal's test, 2 were Brahmins (one a meat-eater), 2 Muhammadans, 4 Goanese, 1 Eurasian and 1 Parsi. He also supports Dr. Row's observations as to the frequency of "para-colon" or "paratyphoid" infection, and he notes that Malta fever and the Leishman-Donovan disease have been recognized by him in Bombay.

Dr. Powell of Bombay City, a very able observer, with large experience, says: "I do not think Typhoid rare in Natives of India, but still it is much rarer than among Europeans in India. During three and a half years (ending November 1904) we have had 32 cases among the Police; 7 Musalmans in a strength of about 550, and 25 Hindus in a force of about 1,750. There are about 70 Europeans in the force, but they are treated in St. George's Hospital" (figures included in statement given), "and the number of cases among them is not available, but the incidence on this class is certainly greater than on Natives*; their average age on joining the force is 25 or 26, and they are mostly old soldiers, which should render them less liable, both on account of age and of previous attacks. * * * My experience of this city shows that enteric is much more prevalent than in rural areas. As Coroner's Surgeon I occasionally meet with cases of sudden death from rupture of typhoid ulcers. I am sure the case of the Bombay Police is *quite exceptional*, and I am unable to account for the frequency of the disease among them as compared with Native troops. Is not the whole lymphoid tissue of the Native less prone to disease than that of Europeans? How seldom their Peyer's patches, tonsils and vermiform appendix go wrong. Though Tuberculosis is so frequent, that of the lymphatics is proportionately much rarer."

The Civil Surgeon of Poona, who has had a very extensive and varied experience during 22 years and who has constantly had European patients with the disease, is of opinion that the incidence of Enteric on Natives is highest among those whose habits (especially dietetic) approximate to those of Europeans, *e.g.*, low-caste Hindus, Parsis, high-castes who can afford to disregard caste "prejudices," like the young Rajput nobles at the Rajcomar College (as has been seen in connexion with the Mayo College), Muhammadans, and other Hindus (Brahmins and Bunniahs) who have been to Europe or who occasionally take European food.

*A subsequent report shows that the incidence is four times greater.

Lastly, in connexion with the series of cases in which the diagnosis was confirmed by the serum test by Major Lamb, previously referred to, the remarks of Mr. Bharucha, L.M. & S., a teacher at the Medical School, Poona, and on the staff of the Sassoon Hospital there, are of interest. He believes that Enteric has prevailed among the Natives in Poona for some time past, but that this was formerly not the case to anything like the same extent. It is steadily gaining ground, but has never prevailed in epidemic form as among Europeans. The hospital register gives 34 cases during the four years from 1901 to October 1904, but this does not include cases seen in private practice. It is understood that all these cases were verified by the Widal reaction by Dr. Bharucha himself, save the few submitted to Major Lamb. He says: "I believe the prevalence of typhoid amongst Natives is peculiar to Poona; when working under the careful and able physicians, Dr. Vandyke Carter and Dr. Cook, and during my service of three years in the large Native hospitals of Bombay, I never saw a single case of typhoid fever, real or doubtful. * * * On coming to Poona, I was struck with the peculiar nature of the fever I met with there, and soon suspected that my belief in the absence of the disease would have to be renounced. Enteric runs a very mild course among Natives; diarrhœa occurs in only half the cases. I have seen hæmorrhage in only three or four, and thus I have had no occasion to verify my clinical and bacteriological data by *post-mortem* examinations; I have, up to date, lost only 4 cases, in which one *post-mortem* was performed and ulcer and perforation made out. As Police Surgeon, I must have performed over 300 autopsies during the past four years, but I have never met with a single case of typhoid amongst them. The majority of cases occur at the ages of 18 to 22 years, but I have had cases in children of from 5 to 10 years old. Most of my cases have been students, a large proportion being medical students. Enteric prevails in all classes, but Parsis and Native Christians appear to be most liable, next Hindus and last of all Muhammadans." (This is based on Dr. Bharucha's experience in Poona, where Muhammadans are in a small minority; thus, for the district the census in 1901 gives Hindus, 920,885; Musalmans 45,790; Native Christians, 14,484).

BENGAL.—As we have given a comparative statement of the cases of Enteric Fever treated in the other three large College hospitals, we may as well complete the list for convenience of reference, though here, as elsewhere, the record has only a very small relative value and cannot be held, and certainly is not intended, to exhibit a true and complete record, nor the true relative incidence on the two classes,—Europeans and Natives.

During the decade ending 1903, the records of the Medical College Hospital, Calcutta, give the following numbers of admissions and deaths among three classes, *viz.*, Europeans, 40 and 10; Eurasians, 21 and 5; Natives, 51 and 15, respectively; no less than 39 of the cases with 9 deaths among the Natives were treated during the last 3 years. This information was accompanied by the statement that two or three Natives were admitted for all causes for every European (Europeans being exclusively treated at the "General" Hospital) and that the number of Eurasians admitted exceeds that of Europeans. The great rise in the cases treated among Natives in 1901-1903 is notable: "I think cases among Natives are proved to be commoner than they were believed to be before the use of the Widal test;" evidently in 1901, as may be seen from Captain (now Major) Rogers' work published in the *Indian Medical*

Gazette of January 1902,* which was followed by his paper read before the Medico-Chirurgical Society, London, in May 1903† and published in its Transactions (Volume 86). These papers deserve close consideration, as upon the thesis they sustain depends in largest measure the case for the prevalence of Enteric Fever among Natives in the largest urban centres. It would be unfair to take extracts from the context of these statements, and there is the less necessity for this as everyone interested in the subject is bound to study them carefully for himself‡: we shall therefore merely note a few of the salient considerations and conclusions. Rogers considered that he had established the facts that among the continued and Remittent fevers met with among both Europeans and Natives in the hospitals of Calcutta, only two specific forms exist, *viz.*, typhoid and malarial remittents, and that as regards Natives "upwards of 80 *per cent* of the Remittent fevers encountered, which last three weeks or more, are typhoid fever." (At the same time only 50 of 126 cases "of all kinds" among Europeans in hospital were pronounced after examination to be Enteric, while 46 were Malarial. There is some danger of this being understood as implying that Enteric is proportionately more prevalent among Natives.) "On the other hand, I have not met with any cases of true Enteric in Natives of shorter duration than three weeks (mild or abortive cases), although they may possibly occur, so that my experience, so far, does not point to this fever being especially mild in Natives, but rather the contrary, for the series shows a mortality of 30 per cent, which is only partly accounted for by the late admission of one of the cases. * * *Clinically they do not differ from the same disease in Europeans, only they tend to be more severe and fatal on account of the late stage of the disease in which they are commonly admitted." It may be added that up to March 1903, the number of cases of Enteric authenticated among Natives by Rogers had amounted to 26, together with others in different institutions in Calcutta and from various parts of Bengal. If all this be so, we can, on the evidence available, only fall back on Crombie's original suggestion of a form of fever ("urban fever") to which the residents of the great cities are peculiarly liable, for the facts of the clinical and *post-mortem* evidence and of the mortality among the classes of the population under medical control elsewhere cannot be strained to conformity with Rogers' results; for the age incidence as given for his Enteric cases includes a large proportion (over half) at ages at or above 20 years, which are fully represented in the Native army and among the prisoners, as has been shown. He also shows (from his experience) that the age incidence of acute Malarial Remittent is similar to that of Enteric "so that no diagnostic import attaches to the ages of the patients in these two forms of fever." He agrees that the "typhoid state" is commonly met with in Natives suffering from other Continued and Remittent, including true Malarial, fevers, and especially in Pneumonia; he has not met with a case of Malta Fever, but says that Cerebro-spinal fever may sometimes be difficult to differentiate certainly from Enteric when first seen; but here he relies on the presence of leucocytosis in doubtful cases of the former disease. "The chief points in which acute Malarial Remittent differs

*Typhoid as a common continued fever among Natives in Calcutta.

† The differentiation of the Continued and Remittent Fevers of the Tropics by the blood changes.

‡ They should be read with Colonel Crombie's address to the B. M. Association, 1904, entitled the "Fallacy of Finalities" (B. M. J., August 20th, 1904) and with the discussion that followed the reading of the second paper (*Lancet*, May 16th, 1903).

(clinically) from typhoid are mainly of a negative character," but the temperature curve is of great importance, though the Remittent type is commonly seen in both European and Native cases; the rises and falls are much more regular and punctual to the hour in malarial cases, while a more persistent high temperature (continued type) characterizes Enteric. "Of course a similar type is common in pneumonia, but here the presence of leucocytosis will exclude uncomplicated typhoid." Owing probably to the previous exhibition of quinine, parasites were only found in 20·7 *per cent.* of acute Malarial cases, but the failure of the drug, in 30-grain doses by the mouth daily for a week or more, does not preclude a malarial origin as is often fallaciously thought, such cases reacting well to hypodermic administration of the drug.

It will be noted that Rogers' conclusions are largely based on the results of the Widal reaction, and on the increase of the lymphocytes in the diagnosis of Enteric Fever; as to how far these criteria are absolutely reliable in cases among Natives we must leave scientists of equal ability to pronounce. It may, however, be noted that as regards the latter test some question has been raised by men competent to appraise its value (*Lancet*, May 16th, 1903); secondary toxæmias from intestinal affections are common and will alter the normal composition and relations of the blood cells. And as regards the former it appears strange that no evidence of paratyphoid or para-coli infection has been forthcoming, but that all the cases appear to be clinically and etiologically of pure *typhosus* origin and course, and the contrast with Dr. Row's Bombay results is remarkable. We have referred to Crombie's reported results of the application of the serum test in the case of healthy Natives of India residing in England, and who had no history of illness that could be identified with Enteric. A word of caution against a too absolute reliance on the results of this test in different races may not be superfluous and we commend to notice the remarks made by Professor Uhlenhuth (*Deutsch. Med. Wochenschrift*, October 19th, 1905) on "Blood relationship and the Precipitin test." The general conclusion to be drawn from the observations discussed by Uhlenhuth, is that, even in nearly allied animals, important differences must be present in the chemical constituents of the blood. How close the inter-relationship must be before these chemical differences disappear is at present an open question. Occasionally the precipitin test has brought out differences in blood constitution even in animals which are zoologically identical. Thus Schutze prepared a serum by inoculating rabbits with rabbit's blood; this serum he tested against the blood of thirty-two rabbits, and in two instances obtained a precipitate. This rare phenomenon, in Professor Uhlenhuth's opinion, must not be explained by the supposition that an "iso-precipitin" has been formed, but ought rather to be regarded as due to a *racial difference in the blood albumens* of the animals in question. And similarly, he thinks, chemical differences may be present in the blood of various races of mankind.

After all, the established facts do not appear to warrant the assumption that the large class of Continued and Remittent fevers can be differentiated under the two heads—malarial and true Enteric, and that 80 *per cent.* of the whole occurring among Natives, the duration of which exceeds three weeks, belong to the latter category. Such a statement is doubtless a misinterpretation of Rogers' views which were formulated three years ago, and in the remarks which follow, no criticism is implied; we wish merely to indicate the various forms under which so-called "Remittent" and "Continued" fevers may appear. If we set down simply the commonest forms of disease already known to occur among the Natives we may appreciate at once how much larger is the range of fevers which assume a more or less remittent type, simulating the pyrexia and other clinical signs of Enteric; and these are not occasional curiosities of tropical pathology, but, in many cases, the commonplaces of practice in this country. We have, *e.g.*—

1. True Malarial Remittent, acute and chronic, from which to judge by the returns (admissions *per mille*) a large proportion of the population suffers and which confers no subsequent protection, and must frequently complicate other specific infections. This is frequently attended by "enteric" symptoms in the non-specific sense, by enteritis (Rogers) and by necrotic lesions of the intestine (Vandyke Carter, Murray, Mannaberg, &c). It is also frequently accompanied by low forms of pneumonia and bronchial catarrh.
2. The disease caused by the Leishman-Donovan bodies, the extent and distribution of which is not yet known, but, so far, it has been found to be most prevalent where Enteric is least recognized. Here again we have intestinal implication, and it was long confused with Malarial Remittent of which Rogers himself considered it a special form.
3. Malta Fever, which has recently been shown to be much commoner among Natives than has hitherto been suspected, and this not by the serum test alone, but by the isolation of the specific organism by Lamb from material received from several different places. (Sanitary Commissioner, India, 1904). Here there is enlargement of the spleen as in the two previous instances cited, and "it may be that it only on the *post-mortem* table that we have the assurance, from the absence of ulceration in the ileum, that we have had to deal with a case of Malta Fever" (Manson).

4, 5, 6. Tuberculosis, Pneumonia in various forms, and Dysentery, are all very prevalent, and all may be complicated by Malaria, and in two of these at least there is frequently hæmorrhage from the bowels, along with intestinal lesions, simulating to the casual observer those of Enteric Fever. Chronic Pleurisy also is extraordinarily frequent, generally as a complication of other primary disorders, but when simple, it is often masked by Malaria and overlooked.

7. Cerebro-spinal fever, the similarity of some cases of which to Enteric has been noted by Rogers.
8. Influenza and its complications; and even Dengue may be mentioned.
9. Pyogenic infections, pyelitis; hepatic, cardiac, splenic and meningeal affections; also those of a gonorrhœal origin.
10. Syphilis.
11. The fever induced by entozoa of which a chart has been given, and in which intestinal symptoms and lesions are often present.
12. Various forms septic throat infection; and of entero-sepsis, leading on to appendicitis and to para-typhoid and para-colon infections.

This list written *currente calamo* leaves little room, in a combined death-rate from *all* fevers among the Native troops and prisoners of about 2 *per mille*, for

13. True Enteric Fever, which, to sum up the conclusions we contend for, is undoubtedly present, but is relatively rare, even though it be overlooked to a considerable degree; and it may be granted that the incidence on urban residents is probably comparatively much heavier than on the 90 *per cent.* of the people who live by agriculture in the villages, as conditions of aggregation (involving propagation and dissemination), diet and occupation must

be expected to operate here as elsewhere. It will be granted that general factors which favour the prevalence of the disease among Europeans will also operate in the case of Natives. Major Rogers reports a double rise in the Enteric curve for Natives, while affirming his belief (based on a comparatively few figures) in a single season of prevalence in the case o Europeans, *viz.*, the end of winter and on into the hot weather. If w take the Punjab where the hot weather rise is most definite and exclusive as regards Enteric Fever (see Charts, Chapter IV), and so most accordant with his observations, and if we compare the seasonal incidence with that of the deaths from "fevers" among the Native civil population, we shall not find much indication of an identical etiology, thus:

Deaths from "Fevers" in the Punjab, Native Civil population.

Jan.	Feb.	Mch.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
138,767	103,773	103,369	95,862	107,962	100,775	86,553	85,686	118,495	175,377	197,179	176,896

Thus 54 *per cent.* of the mortality occurs in the five months, September to January, the period of least Enteric among the troops in the same area. There is indeed an increase in the mortality in May and June, but it is far below the monthly mean, and there is the best authority for the attribution of this small rise in the curve in large measure to "Malarial" influences. Captain James, I.M.S., gives a chart in his first Report on the anti-malarial operations at Mian Mir (*Scientific Memoirs*, No. 6) which shows how *anopheles* mosquitoes begin to increase in April and May with a simultaneous rise of malarial fevers among the troops, the curve showing a fall in June and July to rise to its highest point in October. The seasonal curve of Remittent Fever in the same ("continental") area among the Native troops and prisoners follows much the same course, the acme being reached in the autumn. And, in this place, it may be as well to record the fact that the total number of admission to hospital for Remittent Fever in all the jails was 1,422, during the five years ending 1904, the aggregate population at risk being over half a million. Of these 1,422 cases, 462 were admitted in the Bombay Presidency, and 433 of these during 1900-03, the latter being mostly attributable to famine conditions; and similar instances can be found in other provinces. During the last two years the mean ratios *per mille* of strength of admissions and deaths (jails of India) have been, for Remittent fever, only 2·1 and 0·4 respectively.

An endeavour has been made in the foregoing notes to give the evidence as furnished by those best qualified by their professional status and experience, and as we have reviewed at length the position taken by the foremost advocate for the prevalence of the disease among Natives in Bengal (or rather in Calcutta) it would scarcely serve any useful purpose to extend the references. It may be said, briefly, that several other interesting replies have been received from officers serving in Calcutta and in other parts of Bengal, those working in the capital being in general agreement as to its greater prevalence, though one or two qualify their opinions in a suggestive way. The late Superintendent of the Campbell Medical School and Hospital says: "I am convinced that it is an imported disease. it is rare relative to the entire Native population, and almost unknown in the country districts. Some influence is apparent in the contact in the city with Europeans."

The late pathologist at the Medical College, who was also Police Surgeon, and who performed several *post-mortem* examinations daily, says: "I have come across so very few cases that I hold the disease to be extremely rare among Natives of this part of India. I have seen two or three typical cases in youths of well-to-do Bengali families."

The Professor of Clinical Medicine at the Medical College, who has a large consulting practice, is convinced that "Enteric Fever is one of the commonest diseases amongst Natives * * I look upon Typhoid as just as common amongst all classes of Natives, Eurasians and Europeans as the disease is in Europe." He admits the difficulties of diagnosis from other common fevers "without the aid of the blood test which is rarely obtained," and says "we undoubtedly get cases which fail to show any malarial parasite, fail to react to the Widal test or to that for paratyphoid, and what these cases are I do not know. Clinically I should not hesitate to call them Typhoid, but that repeated Widal's tests fail." In many of these cases there are no intestinal symptoms, and in cases considered to be Enteric, intestinal symptoms are more marked in Europeans and Eurasians than in Natives. "The majority of my cases are in children of both sexes and young adults, but I have seen cases at over 40 years of age."

Dr. Koilos Chunder Bose, C.I.E., who enjoys a large practice in Calcutta, confirms the foregoing statement in many of the main points; but he believes Enteric to be certainly a new development, due to the growth of the population and the increasing congestion of the city site and to the introduction of underground drainage and sewers. It is in the most congested areas and among the well-to-do that he finds his cases, their ages ranging from 7 to 25 years, males predominating. He has not seen a case in the more open suburbs. His experience of the mortality is that it does not exceed 10 *per cent.* "I have tried and often failed to trace the disease to direct infection," a notable point in regard to a disease like Enteric in the most closely congested inhabited site in the world. Lastly, he distinguishes a form of "simple continued fever" which runs a definite course of 7, 14, 21, 28 or 35 days, which he says is easily differentiated from Enteric.

We may conclude this survey with a quotation from the Army Medical Department Report for 1904, which deals with the evidence as regards the prevalence of Enteric Fever among Natives in more or less close contact with the European troops in cantonments. The suggestion that these cases prove the presence of sources of infection for the European troops may be accepted, but it leaves the question of the primary origin of these sources undecided, and it is at least a feasible hypothesis that the European troops themselves may well have been responsible, and that the Natives attacked derived the infection from them in the first instance.

"Colonel Morris, R.A.M.C., reports that at Sialkot one of his officers differentiated Enteric Fever and also Malta Fever in a Native Corps there, which under other circumstances would have been returned as an ordinary malarial attack. Again at Pachmarhi, Major J. Alexander, R.A.M.C., notes he saw in consultation a Native child in the bazar suffering from Enteric Fever, and his Hospital Assistant reported three other cases and doubtless many others occurred and were returned as 'fever.' Again from Kirkee, Major Hale, R.A.M.C., writes—"Natives play a large part in contaminating the ground around barracks and bungalows as there is no doubt they suffer from Enteric Fever as much as Europeans, but up to date it is always looked upon as only being Remittent Fever when they get it. In support of this he notes that three cases which were treated for Enteric Fever in the Native Section

Hospital at Kirkee gave a positive reaction with Widal's test and a fourth case, a native driver who died a few hours after admission, showed *post-mortem* that death was due to hæmorrhage from one of twelve typical enteric ulcers. At Ambala on the contrary after careful enquiries, Lieutenant-Colonel Woodhouse notes that Enteric Fever is extremely rare among the Native population, and Major Morgan, R.A.M.C., who has been two years in charge of the Cantonment General Hospital at the same station, states that during this period he has only met with one case of Enteric Fever amongst his Native patients.

At Fategarh Major Mould, R.A.M.C., draws attention to the prevalence of the disease amongst the Native population, and as there were no cases of Enteric Fever amongst the troops in the previous year, and as far as he could learn no convalescents arrived in the station before the outbreaks, he thinks the presence of infection in the station was originally derived from Native sources. He notes no less than five cases occurred amongst the Natives during the year, four being confirmed by Widal's reaction. If five cases were seen, he thinks the inference may fairly be drawn that very many more were not seen, as comparatively few cases of fever come under the notice of medical officers. Having regard to the habits of the Native as to his evacuations, the infection would be spread broadcast, so it is easy to understand the British soldier contracting the disease notwithstanding all the care devoted to the sanitation of the lines and their vicinity."

Finally, the writer has been favoured with reports from the authorities of a number of the large Colleges and Schools in British Indian territory, but considerations of the space at disposal preclude anything more than a bare summary of the evidence so kindly furnished and for which thanks are tendered. It may merely be mentioned that the replies received from the ten representative Institutions mentioned below, where Native boys and youths are educated, are negative in regard to any history of Enteric Fever, save where noted.

1. C. M. S. High School (Boarding) Calcutta ; one case in nine years.
2. Forman Christian College, Lahore. Dr. Orbison (M.D.) says that during eighteen years' experience, cases have been very rare. Enteric Fever is not nearly so common or so fatal among Natives of India as among Europeans.
3. Rajshahi College ; no case during three years' experience (Dr. H. M. Ghosh).
4. Chapra Boys' School (C. M. S.). Negative.
5. High School, Raipur. No case since the opening, twelve years ago.
6. Jubbulpore College, Male and Female Training Institutions ;—No case during last 10 years.
7. High School, Saugor. No case during 1904, to which period the reply was confined.
8. Central Training College, Lahore. No case during the last four years.
9. Madras Christian College. No records.
10. Muhammadan Anglo-Oriental College (see previous reference). One case (1904) on record. The writer can confirm this statement of the absence of the disease for the period 1891-97.

It is otherwise with regard to half-a-dozen schools at which Europeans and Eurasians only are educated ; *e.g.*,

11. Martiniere College, Lucknow, which has an average establishment of 150 Europeans and 90 Eurasians. There were four cases among the former and three among the latter from the middle of 1898 to the early part of 1904.
12. Diocesan Boys' School, Naini Tal. From 1899 to 1904 the number of pupils has ranged from 60 to 109, fairly equally divided between the two

classes (Europeans and Eurasians). During this time there have been four cases: 2 Eurasians, 1 European and 1 Armenian.

13. Government Schools, Kurseong; present numbers in training, 200 boys and 100 girls. Only four cases during the last ten years; probably imported.

14. Girls' School, Mussoorie; strength not stated. The medical officer reports four cases during the last year, during which alone he held charge. Three of the girls were of pure European parentage, one Eurasian.

15. Lawrence Military Asylum, Sanawar; average strength 380 Europeans and 110 Eurasians, ages ranging from 4 to 17 as a rule. During the period 1898-1904, there are 23 cases on record, of which 16 were in Europeans. The Widal test was employed in 18 cases. In a large number of the cases the infection is believed to have been imported.

16 and 17. Bishop Cotton's School, and the Boarding School at the Convent, Simla. There were fourteen cases in these two institutions in 1904; four in the former, 2 Europeans and 2 Eurasians; 10 in the latter, 6 Europeans and 4 Eurasians.

This completes our survey of the available evidence, and we now sum up briefly some of the provisional conclusions to which it points.

If we assume that the *b. typhosus* is everywhere widespread in the Native environment, we have to explain the fact of the comparative rarity of its reaction on the human host which constitutes the disease we recognize as Enteric Fever, the means of access of the bacillus (if widespread) to the Native host being everywhere exceptionally free and uncontrolled. The only possible explanation is that the soil presented by the human host is unfavourable to the seed, and that is to say, there is a relative and considerable measure of immunity to the attack of the specific micro-organism in question. This immunity may be due to an extensive experience in the past of the individual, or the race, of the effective attacks of the *b. typhosus* or of allied pathogenic organisms; or, possibly, to some subtle properties of the tissues evolved in the race under the conditions of life which mark the civilization in contrast to that of the Northern and Western races. But if we could exclude from account the possibility of the almost universal prevalence of true Enteric among children, it appears doubtful if under such conditions the specific bacillus would maintain its effective viability and ubiquity, for it would probably degenerate into a harmless saprophyte, if it did not disappear altogether; for its maintenance as a "specific" parasite depends on its capacity for setting up a pathogenic reaction in the host. We may assume, at any rate, that this reaction is a necessary condition of its parasitic existence, if regard be paid only to the enormous multiplication of the species and to the maintenance of its specific virulence, which is involved in the effective attack of the host. But this essential biological condition is apparently lacking or, at most rarely present, if the evidence adduced has any weight. The specific germ, if not constantly re-imported, requires a passage from host to host, unless we assume its evolution from a lowlier and commoner saprophytic form of the same genus.

On the other hand, the facts would also be explained on the hypothesis that the *b. typhosus* is generally absent from the Native environment, and only rarely present and confined for the most part to local (urban) centres where the danger of infection from Europeans is not to be overlooked, and where the environment is a recent development and alien to the great majority. Thus the whole tendency of the evidence is to indicate that one or other of the essential factors is absent or in abeyance, *viz.*, the predisposition of the host or the presence in the environment of the *b. typhosus* as an effective pathogenic agent.

One cardinal fact, not to be ignored, is the absence of *epidemic* outbreaks in which all observers, whatever their views on the main point, agree ; and, moreover, it is clear that if there were no natural immunity, cases when they do occur—and no one can doubt their occurrence—would prove almost invariably fatal. A survey of the evidence on this point indicates that the case-mortality is certainly not notably higher than that observed among the European troops, taking all the considerations into account:—the natural resistance to specific bowel diseases and the resources of medical treatment and nursing in the two classes respectively ; it cannot be doubted that a proportion of attacks evades recognition and many capable observers maintain that the case-mortality is much lower. On a review of all the considerations (including the low combined "fever" mortality), the writer is compelled to affirm his opinion, in the present stage of knowledge, that we have in the evidence good grounds for the belief that the disease stands on an altogether different plane as regards Natives in comparison with Europeans; and that the contrast involves essential differences in the factors, the interaction of which connotes what we term Enteric Fever, which in itself can no longer be considered a true specific pathological entity. Thus we are led to the conclusion of a decided measure of immunity on the one hand, and to the rarity in the Native environment of the true and effective *b. typhosus* on the other hand, while, at the same time we must recognize the influence of other parasites, facultative or other, having racial and biological affinities and, possibly, an identical ultimate origin. It may be that Natives are, as it were, on the way to a susceptibility to true Enteric while now subject to the pathogenic influences of the other micro-organisms of the Typho-Coli group, including the agent of Dysentery, or it may be that these latter infections exclude the former. The conditions of life, of diet and metabolism, of climate and of a most insanitary environment are all influences which may determine the issue in a direction contrary to what might well be expected, *viz.*, to an evolution of a greater resistance against the operation of the more common and lowly or primitive members of the series, for it is difficult to account for an immunity from the effective attack of *typhosus* by past experience thereof, with the retention of the susceptibility to *b. coli* and the intermediate organisms.

But in all this we trench on the province of exact research which, while following up the way opened by the work of Rogers, Row, Lamb, and Sutherland, must make the effective bacillus or bacilli its final objective, in all cases of Remittent and Continued fever that cannot be proved to belong to the other categories we have cited. And, fortunately, we have not to confine ourselves to fatal cases, the excreta affording ample material for this purpose. Attention must be directed to the bowel diseases of children, and having regard to the excessive liability to lung diseases, these offer a field for research in this connexion which must be cultivated. We shall then be in a better position to estimate the true nature and prevalence of the disease and of its relation to the Enteric of Europeans, and further, the measure, the quality and the basis of the immunity which the evidence appears to demonstrate. (See Summary at end of Chap. VIII.)

The hope of contributing a few facts to the elucidation of the questions at issue, and which may serve to direct the enquiries of scientific research, may perhaps justify this long dissertation.

We may now conclude with the briefest possible survey of the records of the disease among Natives of other tropical and sub-tropical regions, passing as consistently as possible from West to East. At the same time we shall make no attempt to appraise the value of this evidence, our aim being rather to complete the record and to exhibit the present state of opinion on the subject with a view to facilitating further research.

America. We have already referred to the view expressed by Munson that "Negroes and other coloured races undoubtedly possess an immunity to Typhoid Fever" and we have given the facts from American army experience on which this is based: thus

United States Army.

	White Troops.	Coloured.	Indians.
1887-1896 ...	5·93	2·43	0·47

the figures representing the ratios of admissions *per mille.* By the courtesy of the Surgeon-General, U. S. Army, I am enabled to give the incidence of morbidity and mortality for the last 7 years (ending 1903) in continuation of Munson's record.

Enteric Fever. Mean Ratios per mille of strength.

	White Troops		Coloured.	
	A.	D	A	D
1897-1903 ...	44·4	4·7	8·5	1·9

This period included the operations in connexion with the Spanish war (1898) in which the ratios were, for White troops, 147·5 and 15·26, and for Coloured troops, 27·97 and 6·7, respectively, "in spite of the fact that the Negro regiments saw harder service."

Phillippines. For the Filipino troops in 1902-03, the average annual strength of which was 4,800, the mean rates per 1,000, were 1·4 and ·21, for admissions and deaths, respectively.

West Indies. The opinions of medical officers in practice in British Guiana and the Bermudas, in favour of a relatively large measure immunity from the disease on the part of the Natives have already been given. During the period 1898-1902 the British Troops in Bermuda suffered at the rate of 17·8 and 1·96 *per mille,* admissions and deaths respectively, while there was only one case recorded among the Natives, giving a mean admission rate of ·5. In Barbados, during the same period there were no cases among the Non-European troops. In Jamaica the following is the record :—

	European Troops.		Natives.	
	A.	D.	A.	D.
1898-1902 ...	8·4	2·2	3·4	1·35

Malta. Crossing to the Mediterranean, we come to Malta, the record for which is :—

	European Troops.		Royal Malta Artillery (Maltese).	
	A.	D.	A.	D.
1898-1902 ...	7·9	2·32	0·8	—

Algiers-Tunis.

The facts as to the immunity of the Arabs and Natives of North Africa as shown in the experience of the French army of occupation have already been detailed, as also the observations of Professor Vincent in this connexion (see Chapters V and VIII). It may be mentioned that Brault (of the Algiers School of Medicine) has confirmed Vincent's results, and in order to determine the question of immunity acquired in childhood, he applied the Widal test to the blood of 40 children (from 4 to 14 years of age) with the results that 34 gave an entirely negative reaction ; in 4 cases it was doubtful, and in only 2 positive. He concludes that the immunity of the Arabs and other Natives of Algiers-Tunis, is natural (innate) and not the result of a previous attack in infancy. (Soc. Medicale de Gand.)

We shall merely give the briefest summary of the facts on official record for the whole French army of occupation (Algiers-Tunis) for the 5 years ending 1902. In many of the 22 units located in the Colony, Natives and Frenchmen are mixed in uncertain and varying proportions ; we shall therefore take the corps in which " black " troops alone are on the rolls and compare the incidence on them with that on the whole army of occupation (Native and European) :—

Ratios per mille of strength.

	1898.		1899.		1900.		1901.		1902.	
	A.	D.	A.	D.	A.	D.	A.	D.	A.	D.
Tirailleurs Algeriens*	4·4	0·82	8·70	1·02	6·49	1·33	3·67	0·68	2·05	0·54
Spahis*	10·26	1·47	15·37	2·61	6·73	1·96	7·46	—	5·79	1·38
Army as a whole ...	23·47	3·57	32·07	4·43	23·92	4·95	21·55	3·56	17·80	2·88

* " Black " Troops.

Of course, the contrast would be still more striking if the results for the " black " regiments were separated from those for the army of occupation as a whole.

Egypt and Soudan.

To the case of Egypt we have referred more than once ; here are the figures and the comparison given by Sandwith, whose conclusions have been quoted at length (Chapter VIII) :

		Average Strength.	Average cases of Enteric annually.	Ratios *per mille.*
English Army in Egypt	1888-1902	4,045	105	25·9
Egyptian Army in Egypt	1892-1902	2,837	5·8	2·0
Egyptian Army in Soudan	1892-1902	15,323	32·6	2·1

The incidence on the Natives is, therefore, less than one-twelfth of that suffered by the Europeans.

For the Soudan there is the testimony of Caldwell already quoted (Chapter V), which is confirmed by Dr. A. Balfour, Director of the Research Laboratories and M. O. H. Khartoum (see his report 1904, page 55), " Enteric Fever—Natives apparently unaffected. The disease is rare." He kindly adds in a letter to the writer: "There is of course Enteric in Egypt and we get 'birds of passage' developing it here, but we have never had an epidemic, and considering our present water-supply (the river bank being fouled by excreta) we should have been scourged ere now, if the disease were at all "common." And, again, "I have not seen a single case in the civil hospitals at Khartoum and Omdurman."

The Prinicpal Medical Officer at Khartoum has most kindly furnished a statement of the record of cases amongst Egyptian and Soudanese troops during the last four years, of which the following is a summary :—

Enteric Fever admissions among Native Egyptian and Soudanese Troops at all Stations,
1900-04.

Station.	Total cases.
Cairo ...	21
Assuan ...	5
Wadyhalfa ...	3
Dongola ...	7
Khartoum ...	13
Omdarman ...	15
Kassala ..	7
El Duem ...	1
El Obeid ...	2
Berber ...	3
Shendi ...	2
Sennar ...	1
Total	80

This gives an average of 16 cases *per annum*; the average strength in Egypt and the Soudan is said to be about 17,000 to 18,000.

The P. M. O. adds: "Egyptians and Soudanese are not nearly so subject to Enteric as Europeans. During an experience of 13 years I have never seen a serious outbreak amongst the Egyptian or Soudanese troops either in Egypt or the Soudan. Enteric Fever occurs throughout the Soudan *especially in the large towns*, but the cases reported are very few (see table). During the last two years the ratio of admissions *per mille* of strength of the troops, has been ·8 (1903) and ·6 (1904), and most of the cases occurred at Cairo."

South Africa.

In regard to South Africa, the writer has received most generous replies to enquiries from Dr. Turner (Census Commissioner, and formerly M. O. H., Transvaal) and from Dr. Hill, M. O. H. of Natal, but the results are so inconclusive, owing to defective Census data and to defective notification of disease and registration of deaths among the white and indigenous populations, that any attempt at a summary would be dangerous and misleading. It may be noted merely that on the *recorded* facts for Natal, both Asiatic immigrants and S. African Natives are far less subject to the disease than Europeans. Dr. Hill's report deserves quotation at length, but as space forbids this, I shall merely note that he points to the probability of the inclusion of Paratyphoid fever in the returns and, further, he remarks that the recent Boer war was responsible for the propagation of the disease, owing to the fact that Natives employed with European troops contracted the infection in the field, and on return to their home, communicated it to their families or to other Natives with whom they stayed *en route*. We must turn to the records of the Zulu war (1879) for the most authentic evidence of the relative immunity of Natives, in the case of the "Black Irregulars" (operating with the English troops) which was cited in Chapter V.

We pass next to the region intervening between Africa and India and including Persia, Turkish Arabia and the Persian Gulf, the information being derived from the few stations at which officers of the Indian Medical Service are posted. From the nature of their duties, which are semi-political, and the comparative brief periods of their service in these remote places where the civilization does not include vital statistics and registration among its fruits, it is not to be expected that the evidence based on hospital practice (which is in the early stages, and carried on under considerable difficulties) will be very conclusive.

Meshed and Baghdad.

There is a general agreement that the Turkish "hakims" have nothing to say on the subject for the very cogent reason that they do not recognize the existence of the disease, but devote their talents to a whole-hearted endeavour to suppress the most prominent symptom in any case that falls into their hands, by the use of drugs. They have no "how" nor "why" in their philosophy, and the traditions of Alhazen and Avicenna do not disturb their mediæval attitude. At Meshed (Persia) and Baghdad (Turkish Arabia) little or no effort is made in the direction of public sanitation; nearly every house has its uncemented cesspits which receive all the waste-water and refuse; the latrines are separate and are "cleaned" out from time to time, and the excreta are either thrown into the river Tigris (in the case of Baghdad) or dumped upon the desert. At Meshed, the Dispensary records are valueless; at Baghdad, the Residency Surgeon has treated 7 cases during the eight months ending January 1905. One was a European adult; one a Native Christian child; two Muhammadans, one child and one woman; three Jews, all women. Among the British community, numbering about 25 persons, there have been 5 cases during the last three years. There is no record of the disease in the Indian Sepoy escort. "Enteric fever hardly seems to exist among the wandering Arabs; it occurs only in towns or large villages."

Muskat.

The Agency Surgeon, Muskat, says that during his 20 months' experience of the place he has not met with a case either in hospital or private practice. The hospital records for several years were searched, but gave no evidence of the disease among Natives, but there are 3 cases on record among blue-jackets who were landed for treatment from one of H. M. ships. The population consists chiefly of Arabs, Biluchis, Persians, Afghans and Natives of India.

Bushire.

The Residency Surgeon at Bushire (3 years' experience) had not seen "any well-marked case of Enteric Fever", until the autumn of 1905, when "4 severe cases of the Typho-malarial type were treated by him, one European child and three Natives"; two of the latter died on 20th and 31st day of illness respectively. He further gives a list of 24 cases among Natives treated in the Dispensary during 13 years, 1891 to 1904, the average number of Natives treated annually (all causes) being about 7,000. "The Persians who come into this list do not represent all the cases which occurred in Bushire during the period. They are a few of the more enlightened people who came under the notice of the Residency Surgeon." He encloses a letter from a French physician, who had served in the Army and had practised for 18 months in Bushire, who states that in his experience there and in the French tropical colonies, the disease is very rare among the Natives.

Bahrein, Bussorah.

From Bahrein, Dr. Patterson reports that the experience of six years' medical work in which two European physicians have been engaged, has been negative in respect of Enteric Fever among the Natives until the summer of 1904, when a Syrian boy (10 years), whose people had been in close association with Europeans, was believed to have been attacked. As for Bussorah, one case has been diagnosed in an Arab during 10 years' work carried on by two English doctors, one of whom has special experience of practice among the women and children without encountering a case among them.

Ceylon.

The physician in charge of the General Hospital, Colombo, who has many years' experience of medical work in Ceylon, says "I have always held the opinion formed from a very large experience of Enteric in Ceylon, that the coolies from Malabar (S. India) enjoy an immunity from the disease. I cannot recall a single instance of it among them. As regards the other races, Europeans seem most liable,—young men just out from Europe. The indigenous population suffer a good deal from it; —they live in very insanitary surroundings." He adds as evidence against the theory of the immunity of the Malabaris being acquired by previous attack, in infancy, that the children born of these immigrants on the island also enjoy the immunity. The population of Ceylon amounts to $3\frac{3}{4}$ millions, and the Reports of Sir Allan Perry show the following numbers of cases and deaths *recorded* during three recent years: 1899, 170 and 61; 1902, 243 and 63; 1903, 358 and 71, respectively. Of course, notification and registration is far from complete. It is recognized that the disease is often imported from ships entering this busy port.

Bangkok, Siam.

Dr. Campbell Highet, of Bangkok, kindly informs me that he is accustomed to see cases regularly among the Siamese inhabitants of the city, and he summarises his experience as follows: young Europeans newly arrived are most susceptible; the Native of Bangkok itself is not so apt to contract the disease as a countryman who comes in to join the Police, the Army or Navy, &c.; and, finally, Europeans are more susceptible than Natives, as "I have as many cases amongst a few hundred Europeans as amongst as many thousand Natives."

Straits Settlements.

Dr. Brown, of Penang, whose experience of this region is unrivalled and who has devoted special study to the subject, is good enough to offer the following interesting observations: "Excluding Malaria (and the blood of all cases was systematically examined for parasites) the usual fever from which the Natives suffer is one with a typhoid temperature, tongue and spleen, but no diarrhœa, no spots nor hæmorrhage from the bowels. It is prevalent during the hot dry weather among all races. True Enteric with spots, diarrhœa, &c., is common among Europeans and especially in children. In the first-named fever I have not been able to find parasites nor spirilla; nothing abnormal obtained by Spleen puncture. In 1897, I found that most (not all) of these cases reacted to Widal's test, and I concluded that they were Enteric after all. Further experience of that test and the use of controls, have taught me, that valuable as it is, it must be used in the tropics with even more discrimination and care than in Europe. The fact is that many healthy adult Chinese in the Straits give a positive serum reaction again and again if tested at intervals of six months. The only conclusion I have been able to form is that the immunity is acquired in childhood and is more persistent than in Europe. But though I have tested many cases (about 150) I have never known any patient showing a positive reaction to acquire a serious infection of fever. If there is evidence that the Widal test is doubtful because many healthy persons give a positive reaction, there is also evidence that it is only persons who are negative thereto who become ill. On the whole, I agree with the general opinion in the Tropics, that Natives are as adults almost immune to Enteric, and that immunity has been acquired by attacks in childhood." Dr. Brown adds that his cases were distributed proportionately as follows:—well-to-do Chinese, one half the whole; Europeans, merchants and miners, one-fourth; Malays and Southern Indians, one-fourth. It is probable that we may see in this account evidence of Paratyphoid infections among the Natives.

Malay Peninsula.

From the Institute for Medical Research, Kwala Lumpur, the Director, Dr. Daniels, kindly sends a few notes of the opinions of some of the State Surgeons. One Surgeon knows of 3 cases only (Europeans and Eurasians):—"amongst the Malays it is said not to occur in the Native villages, but occasionally it does occur in the vicinity of

European Stations. No *post-mortems* are allowed on Malays. In 7 out of 400 autopsies on Chinese (who are immigrants) Enteric lesions were found. Amongst Europeans, especially in the towns, it is commonly diagnosed, and some of the cases, but by no means all, give the Widal reaction."

Dr. Travers, of Selangor, very kindly informs me that any record of cases outside the Government hospitals is valueless, because the registration agency is quite untrained (Malays or Sikh police). "I can only state from personal experience during the last 17 years that I should say Enteric is extremely rare among the Malays and very uncommon among the other nationalities." He gives a statement of the cases treated in the State hospitals, which is reproduced, and as regards which he lays stress on the reliability of the records of the General and District Hospitals (Kwala Lumpur) as being the results of diagnosis by English Surgeons; six of the cases were confirmed by *post-mortem* examination.

Enteric Fever in Selangor for three years, 1902-1904.

	Cases of Enteric.	Total cases treated (all causes).
*General Hospital (Kwala Lumpur)	22	6,721
*District Hospital (Kwala Lumpur) ...	31	12,941
†All State Hospitals (Selangor)	83	46,917
Total Natives ...	136	66,579
*Population of town, Kwala Lumpur		23,381
†Total population of State (1901)		168,302

During the same period 5 cases of Enteric in Europeans were treated in the hospitals, the number admitted for all other causes being 136; the European population at the Census (1901) was 487.

Singapore.

The case as regards Singapore is stated by Dr. Galloway, whose experience goes back to 1884, and who is good enough to give the following interesting remarks:

"With a plethora of fevers of all kinds and in the absence of any diagnostic test (at that time) I certainly met with but few cases which filled my concept of Typhoid fever, but an unexpected light was thrown on these by the occurrence of an outbreak of a continued fever in the Jail, all the fatal cases of which shewed, *post-mortem*, true typhoid lesions. From a study of the clinical features of that outbreak we were able to know that many of these cases of continued fever, which had previously escaped notice, were really Typhoid. Now with the aid of Widal's test all uncertainty is past, and we have learned that Typhoid is not at all rare and that natives are the chief sufferers. The age of incidence is in the second decade of life, and my strong impression is that, with the growth of the city, the type is becoming more severe and more akin to the classical. As to the particular query as to whether the occurrence of typhoid has any relation to contact with Europeans I think that can be met by a decided negative. Typhoid among Europeans is rare or, at least, not common, and Singapore is peculiar in that the European and Native quarters are quite distinct as to drainage and, until recently, water-supply. It is impossible to state whether it owes its introduction to European influence, but I should think it unlikely in view of the prevalence of Typhoid in Native cities in China from which most of our immigrants come."

In an account of the vital statistics of the Dutch Navy for 1897, it is stated that

Dutch Navy.

the *personnel* exposed numbered 17,254 Europeans, 32,833 Asiatics and 80 Africans; there were only 37 cases of Enteric Fever recorded, of which 29 occurred among the Europeans. (*Lancet*, January 27, 1900.)

For the facts and opinions regarding the prevalence of the disease in Hong-

Hong-Kong and China.

Kong, we may refer to Dr. Cantlie's article in the *Practitioner*, January 1904, and to the full extract given in Chapter VIII from Dr. Hunter's Report for 1904. Cantlie sums up as follows: "Typhoid is rare among the Chinese. Chinese children are liable to Typhoid, even more so than European children." In support of the latter opinion he cites an instance of six cases occurring in a Home in Hong-Kong, into which the infection was imported by a German pastor who came from the interior of China suffering from the disease; "after his death 6 children ranging from six to seventeen years of age, contracted the disease, showing that Chinese children are as liable, if not more liable, to Typhoid than are Europeans of the same age. This case supplies food for argument in two directions: first it shows the liability of Chinese children to the disease, and, *therefore* (our italics) "that the apparent immunity of the adult is due to child infection. Second, seeing that Chinese children are so liable to the disease, the typhoid germ cannot be very prevalent in China, or more children would be found suffering from the disease". We cannot follow this logic; if adult immunity (as to which his paper is full of testimony so far as the evidence is available) is due to "child infection", it would seem to follow that most children are attacked and that therefore the germ must be very prevalent, which however he concludes is not the case, because so few children suffer from the disease. The statements on page 38 and on pages 42 to 44 (*Practitioner*) give a good summary of the available evidence and of the prevailing opinion on the question of the relative prevalence of the disease among the Chinese, which is summed up in the statement that "amongst the Chinese, typhoid is a rare complaint anywhere"; and "all reports seem to point to the European's liability to the disease, and in some places to 'ten times the extent' of its prevalence in Britain".

Dr. Maxwell has contributed an instructive paper on "Typhoid Fever among the Natives of Southern China" (Amoy) of which the conclusions may be summarised: (1) Typhoid occurs sporadically, or may spread to the members of a household, but is unknown in epidemic form in China. (2) It is uncommon amongst Chinese children (Maxwell has met with no cases). (3) The symptoms conform to those generally met with in Europe, but, as a rule, they are less pronounced. (4) The disease is attended by a not-insignificant death-rate. In a series of 55 cases observed by him and a fellow-practitioner, the case-mortality was 20 *per cent.* During the same period there were 26 cases among the small European community with 4 deaths, equal to 15·4 *per cent.* Dr. Maxwell has observed only one case of "paratyphoid." (*Journ. Trop. Med.*, June 15th, 1903).

The writer has to express his hearty acknowledgments to several officers of the Indian Medical Service now, or recently, in medical charge of the Indian Force in occupation since the advance of the Allies on Peking in 1903, for much information collected from medical men practising in various parts of the country; and his thanks are especially due to Major Westropp-White and to Major Ozzard in this connexion, who were able to obtain statements of the experiences and the opinions of many observers of high repute. Lack of space precludes more than a bare summary of the more important facts elicited. The general consensus gleaned from more than a dozen letters on the subject supports the view that Enteric Fever is frequently recognized among the Chinese, but that it is relatively rare in comparison with European experience, although all the conditions in which the Natives live are favourable in the highest degree to the prevalence of the infection. Dr. Moorhead, of Tongshan, whose professional attainments are widely recognized and highly esteemed and whose experience is probably unrivalled, (as he is in charge of the Chinese hospitals attached to the Mines and other Engineering undertakings in which upwards of 100,000 men are employed and who, in case of illness necessitating absence from their duties must obtain a certificate from one of the hospital staff stating the nature of their complaint in order to obtain their pay and escape fine) remarks :—"I am therefore able to say that among the adult working males Enteric is a rare disease." His opinions have such unquestionable weight that some of the most important, from an epidemiological point of view, may be quoted.

"Enteric is not so prevalent among Chinese as among an equal number of Europeans. It is not nearly so prevalent a disease in China as in Ireland. It attacks Chinese as in the case of Europeans principally between 18 and 25 years of age. It is more prevalent in autumn than in spring, and I have seen it only during September, October, November, March, April and May; the climatic conditions during these months resembling our mild autumns at home. The disease is usually mild though severe cases do occur. I think it is the exception rather than the rule for ulceration to occur. I have seen only two cases with severe intestinal hæmorrhage, and one case in which there was perforation—due to gross dietetic indiscretion." (In most other clinical features, and in respect of its course, relapses, complications and sequelæ, the disease is as a rule in all respects much less severe and fatal than in Europeans). "I am aware that it is generally believed that the rarity of enteric among Chinese adults is due to protection by the disease acquired in childhood. I can find no facts to support this and it is contrary to my experience. I do not find the disease very prevalent among children. It may be that children suffer from it in so mild a form that they are not brought to the doctor, and the cases I do see are generally mild."

The following statement gives the results of four years' hospital experience :

1901-1904 (*inclusive*).

	Cases.
Total patients treated (all causes)	147,367
Total medical cases	58,138
Trivial ailments	11,725
Medical cases among adults (exclusive of trivial ailments)	18,089
Ditto, under 5 years of age	8,324

Enteric Fever.

Adults	20 cases	Certain.
Under 5 years	3 "	
Adults	41 "	Probable.
Under 5 years	7 "	
Adults	139 "	Doubtful.
Under 5 years	23 "	

The 23 cases in the first category (Certain) were established by Widal's test; the 48 "probable" cases were such as did not react to the Widal test, or where this was not employed, but in which the clinical symptoms (except the rash) were unmistakeable. The "doubtful" cases are more open to question, but still the symptoms were more or less pathognomonic.

The testimony of medical missionaries in various more or less remote parts of the country is, as a rule, even more negative in its character, but statistics are not forthcoming owing to the destruction of hospital records in the Boxer rising in 1900.

Finally, the writer has good reason to believe that the Chinese Coolie Emigration officers, through whose hands many thousands of men (at the early adult age) have recently passed after undergoing a scrupulous medical examination, could testify to a remarkable absence of the disease among them. It would be interesting to hear what the medical officers in the Transvaal mining camps have to say upon the subject, but so far, it is believed that the usual experiences attending such aggregations in the case of Europeans, have not been forthcoming.

We may commend to the reader an able summary of an article in the *Revue d'Hygiene* from the pen of Dr. Brunet on the influence of diet in China on Natives and Europeans. (*B. M. J.*, July 1st, 1905). To quote:—

> "In the country the diet of the labouring classes is almost exclusively vegetarian (Millet) and in those public institutions, such as orphanages, prisons and hospitals, which are under European management and where a proper account of the dietary is kept, meat only plays a small part in the bill of fare and may even be absent. But Dr. Brunet finds that the Chinaman thrives remarkably well, in spite of the absence of meat from his food. The country labourers have exceptional powers of resisting fatigue, although experience has not taught them the value they might derive from sugar as an adjunct to their vegetarian diet. He adds, what is well known, that the Chinaman never drinks plain fresh water, but almost always submits it to boiling first. Then "there is a great variety of animal food, almost every sort of mammal, bird, fish or shell-fish being utilized for culinary purposes."

But though not expressly affirmed, the latter statement must refer to the towns and the coast, and it is possible that in the local contrast of the staple dietary we may find a clue to the differences of opinion which have been expressed as regards the incidence of Enteric Fever, and we might expect the crowded towns and ports (where animal food is largely consumed) to be associated with a greater prevalence of the disease. Intestinal disorders are rife as in India, but Dr. Brunet remarks on the extreme rarity of appendicitis among other diseases.

The whole tendency of the available evidence is to indicate that the Chinese are certainly liable to Enteric Fever but to a much smaller extent than modern Western communities, and that, in view of Dr. Hunter's results (quoted) derived from a large series of autopsies, any special immunity that can be ascribed to the race is not due solely to more frequent attacks in childhood; further, here as in India, there is an almost total lack of evidence of epidemic prevalence. Beyond this, we may not overlook the probability that to paratyphoid infection is due a large part of the results as hitherto disclosed.

Japan.

In conclusion, one small contribution to the statistics of the subject in the Far East is available from a Report on the medical aspects of the naval operations in the war between Japan and China in 1894-95. During 18 months the total casualties (excluding killed and injured in battle) in the Japanese Navy amounted to 7,106 cases, of which 215 were fatal; Enteric Fever accounted for 131 cases and 24 deaths. (*Lancet*, Oct, 16, 1897).

As to the immunity of the Polynesian Islanders (Fiji, etc.) the testimony of Sir W. Macgregor, M.D., has already been cited.

It remains to be noted that the incidence on British troops serving in China, Japan and the Straits is altogether incomparably less than that suffered by their comrades in India and Egypt; this can be only partly due to the elimination of susceptible subjects in other tropical and sub-tropical garrisons before arrival in the Far East. At the same time it cannot afford any true measure of the prevalence of the disease among the Natives of these respective countries, for, on the whole, Enteric and the allied infections appear to be more prevalent among the Natives of the Far East, especially when compared with Egyptian experience. The conclusion of the whole matter must be, then, as contended on other grounds, that we must look to the conditions inherent in the *personnel* of the British army on foreign service, rather than to the presence or absence of infection in the native environment, to explain the epidemiological facts.

CHAPTER X.

Conclusions and Indications. Prophylaxis and Suppression.

In offering the following remarks on the practical indications which may be deduced from the whole body of evidence presented in the foregoing pages, the writer would disclaim the intention of affording more than a suggestive treatment of this aspect of the subject. He has endeavoured to review the facts impartially, and while conscious that he has not risen to the height of his argument, he regards his specific task as completed at this point, for the rest depends mainly upon the judgment to be awarded to his interpretation of the evidence. Moreover the essential principles of prophylaxis are now well-established, and it is only in their rational application and direction that we are called upon to revise our methods if it be demonstrated that the current conceptions of the etiology are partial and inadequate and disproportionate to the weight of the evidence. No one can doubt, for instance, that the infection of Enteric Fever is frequently conveyed by specifically polluted water, nor again, that the Natives of India are liable to the disease, but as a basis for a complete working hypothesis these facts are totally inadequate alike to explain the epidemiology and to indicate successful preventive measures. Indeed, on the contrary, they have proved a stumbling-block. With the advance of knowledge there is an irony in the fate that makes one established truth the enemy of another and a greater, but "truth is truth in each degree," and the scientific method must adjust values if we are to escape the most blinding form of error—partial truth. The aim pursued in the foregoing exposition has been to re-examine the evidence critically from all sides, to readjust the weight of its components in relation to the whole, and so to arrive at a juster conception of its bearing on the practical problem. If this has been attained, the actual working details of a rational prophylaxis need no laboured discussion, for they emerge as logical deductions of the thesis and it only remains to readjust our efforts in accordance with the altered conception. But with readjustment must go concentration of effort, clearly directed by the etiological indications; to the promotion of the natural resistance of the host, to the destruction of the infective agent and to the rupture of the chain of infection.

We may set forth as briefly as possible the essential considerations on which the plan of campaign must be constructed. These fall naturally under the three main heads of the human organism exposed to risk, the chief sources and means of infection and the environment, as to each of which our remarks may take the form of a summary of some of the more salient points brought out in the previous discussion in so far as they bear directly on the practical problem.

In dealing, first, with the *personnel*, it will be convenient to include the indications to which the chief considerations give rise, in so far as they provide a basis for prophylaxis in the earliest stages, *i.e.*, up to the time of the arrival of the men in India. This will clear the way for the discussion of the task that awaits us in cantonments. It is well established that the liability of European soldiers to contract the infection of Enteric Fever stands in inverse relation to the length of time they have been exposed to the Indian environment, and further that this liability is definitely associated with certain age periods on which the morbid incidence is greatest everywhere. If then we can effectively check or minimise the risk of infection of men under 25 years of age and of all during the first two years of service, we shall cut at the very root of the evil. The danger lies in the "predisposition" of the tissues of the raw individual born and bred in Great Britain when first exposed to the influence of the Indian environment, which operates not only generally to lower resistance, but to provide abundant sources of infection. The physical and mental characteristics of the raw material out of which the British soldier is evolved have been sufficiently indicated in Chapter I., where also the notable changes which have marked the *personnel* as a body were graphically depicted. We recognize, further, that health is a question of due adaptation, that the necessary physiological adjustment is the resultant of the interaction of the extrinsic forces (climate, food, occupation) and of the inherent constitutional qualities with which each man is endowed at birth in varying measure, and that any great change in either direction will upset the balance. But in the case of the modern soldier transported direct from his natural habitat to the tropics a double disability is incurred: the predisposition of the last generation has been increased by non-elimination of the most susceptible as a result of the great advance in all measures affecting the public health, and especially in regard to conservancy, and by the effects of the short service system in lowering the age and in necessitating a larger annual supply of drafts to maintain the strength. And, on the other hand, there is the strain imposed by the sudden and extraordinary change in the environment taken in its widest sense. We have to regard the striking phenomena of the deadly effects of exposure thereto during the first few months, along with those which are connoted by the term "acclimatization"; our object must therefore be to pursue the indications to which these converse phenomena provide the key. That some of the factors are beyond our direct control may be conceded, but this fact should stimulate vigilance and resource in the application of indirect measures against the root elements of the evil—the predisposing conditions,—in addition to the concentration of our forces where both predisposing and exciting causes are open to a front attack.

So far as the *personnel* is concerned, such measures must take account of all the factors in operation, both general and special, to which attention has been directed, and they must be based from the outset on a comprehensive view of the whole problem: the physical and mental character of the raw material—the recruit—the conditions of service, the effects of long and short service respectively, of first exposure to an alien environment and, conversely, of previous experience. They will strive to make the imperial responsibilities of the army subserve the end in view while minimising the risks these involve, by attention to the details of the system of reliefs and drafts, by precautions on the voyage and on arrival, including the season of arrival and the distribution of the men to their final destinations.

In the application of these indications one of the first and most important steps is to secure the intelligent co-operation of both officers and men by systematic education in the essential elements of hygiene, specially directed to the simple service each man owes to his own body as well as to his duty to the community under the conditions of service at home and abroad. The subject, including its historical aspect, should be given its proper place in the curriculum of the military schools, and officers would then be prepared to co-operate with the medical staff in bringing the best influence to bear upon their men which would reinforce the instruction which should form part of the training of the recruit.

Systematic instruction of selected non-commissioned officers and men should certainly be instituted. If this is held to be necessary in the subjects of agriculture and dairy-farming, the case is far stronger for a new departure on similar lines in the matter of training in the essentials of practical hygiene. Sanitary reform can only be accomplished by the establishment of a subordinate staff competent to maintain a high standard in the details of the work. Let liberal inducements be offered in the way of staff allowances, etc., and then secure the services of competent men of high character by the test of examination after careful instruction, and no more promising investment of public funds could possibly be made. The excellence of the papers submitted by many of the quartermasters at the examinations of the National Health Society just before the South African war, showed the interest taken by them in the subject, and in view of the duties of the quartermaster there can be no question of the value of such training which should be systematized and extended to both officers and rank and file. The modern soldier will readily respond to the claims of some intellectual interest that is presented in a sympathetic and practical form and which will enlarge his narrow view of his functions and incite or rehabilitate his sense of responsibility. The results achieved by the Army Temperance Association afford a good augury of success, while the history of the past sufficiently proves the futility of the best measures applied from outside when opposed by ignorance and indifference. We must substitute for this, which at best rises to a perfunctory blind obedience under supervision, a willing spirit of co-operation, a sanitary conscience and a will, —in short, a healthy sense of personal responsibility and a higher standard of public opinion. But to this end we must be leaders and emulate the wisdom of the greatest soldier, of whom it was said: he had never an "ito" in his commands, but only a "veni." (Cicero on Julius Cæsar). An old tradition dies hard, and though we have progressed very far from the state of opinion to which expression was given in the monstrous dictum of Lord Melville, in the House of Lords in 1808, that "the worst men make the best soldiers," we have still to recognize fully our responsibilities on the true and opposite view and the power which this would give us.

The evidence in favour of the utilization of some of our sub-tropical possessions, and notably of the high veldt of South

Africa, as acclimatization grounds, has been discussed (Chapter II.) and, for the rest, we need only emphasize the need of proper care to preclude as far as possible the embarkation of infected men and to secure them against the risks of infection *en route.* The arrangements on troopships must be directed by scrupulous regard to hygiene with special reference to the conditions of aggregation and of the disposal of excreta,—common dormitories, refectories and latrines. The writer was once in medical charge of a transport, a converted "liner," in which 400 invalids with women and children were conveyed from Bombay to Plymouth. The passage was made during the monsoon, all hatches being battened down for six days, and the conditions set up among this seething mass of humanity are indescribable. The sick and convalescent lay huddled together in their blankets on the deck in darkness, without a possibility of ventilation, and many cases of dysentery were not discovered till a late stage as the patients were too apathetic from misery to call for aid. By good fortune we emerged from a terrible experience without loss of life and, doubtless, all the arrangements are now infinitely better ordered, but it is for others to say if they are perfect, specially in respect of a properly adjusted diet and to systematic exercise. We may, however, call attention to the risks involved in the transport of sick and convalescents along with the healthy, or even in the same ships as those used for the conveyance of outward bound drafts and reliefs, without radical measures of disinfection between the services. There are also the risks incurred by visits paid, and by the embarkation of drafts, at the ports of call along the route, as well as from the food and fruit, etc., supplied by bumboat hawkers. The same considerations are still more applicable to the journey across India after arrival, for it must be remembered that the annual stream of arrivals is equalled by that of the departures, and that both flow along the same routes. The sanitary arrangements (in their widest sense) of troop-trains may be susceptible of improvement, and the abolition of the system of daily halts at rest-camps *en route* is a measure which has too long been delayed. It should be possible to provide sidings for the troop-trains apart from the public stations, along the main lines, where every provision should be made for the necessary supplies and which would prevent the risks attendant on resort to latrines, water-supplies and restaurants open to the general public. The troop-trains should possess their own cooking equipment, and be dependent on the sidings merely for supplementary food and water-supplies and for latrine accommodation. But there should, of course, be no facilities offered by the arrangements for the possible infection of the healthy new-comers by the time-expired men and invalids despatched along the same routes in the reverse direction. In addition to these efforts, nothing can be of more practical importance than the judicious employment of a measure of quarantine for all troops on arrival, and it is only a question as to where and how this can best be carried out; whether at Bombay or Karachi (where the disease is at a minimum), at some selected site upon the Western Ghats, at one or more convenient places in the lower Himalayas (for the Northern and Eastern Commands) or eventually at the cantonments of destination. Nothing is more clearly demonstrated than the facts of importation of the infection unless it be the futility of measures (*e.g.*, removal to the Hill Stations) taken after the new men have mingled with their comrades in rest camps or cantonments. In deciding this question much will depend on the view taken of the effect of first exposure to the tropical environment in predisposing to infection, and of the value of the power of acclimatization. If this be given its due weight (in the writer's opinion) the men should not be allowed to enter their allotted cantonments in the plains until after a sojourn in the Hills to which they should be despatched direct, and with the utmost expedition, from the port of arrival. Indeed, the whole question of the judicious utilization of the resources we possess in the Hills appears to need reconsideration, now that the principle is accepted that one paramount function of the army in India—the maintenance of internal peace—may be deputed largely, if not entirely, to the civil powers, and now that under the scheme for the redistribution of the forces, a far larger number will be massed on the strategic lines in proximity to the Himalayas. There would seem to be no insuperable difficulty in raising the number of men so disposed during the period from March to October, from the present average total of 13,000 to twice the sum, and so securing that all under 25 years of age and with less than two years' service should have the benefit of one of the finest climates in the world. And if we could reduce the Enteric Fever mortality to its minimum, we should wipe off nearly half the loss due to deaths from all causes, and about one fourth of that arising from sickness, with a larger proportion of the consequent invaliding. This calculation is based on data already given (Chapter II.) but the results would be even more striking if the arrangement were carried out systematically year by year in regard to all the younger and newly-arrived men. The experience gained as to the extraordinary vigour and health acquired by the men when employed on road-making in the Hills in 1863-72 is very pertinent in this connexion (Chapter V., page 253) and may point to the way to similar employment in future.

Although it is anticipating the order of our discussion, it may be said here that the principles laid down should be enforced practically to control the risks arising from interstation movements, and from the aggregation of different corps units on mobilization for manœuvres and campaigns. We have seen the lamentable results following the movements of infected corps units ; a regiment leaves a local centre of infection and will often propagate the disease along its course, sometimes without giving evidence of its fatal influence among its own men ; but other bodies with which it comes into contact, direct or indirect by association or by following in its track, will suffer. Such a sequence of events may well provide an epidemiological "mystery," and baffle detection of the source of infection.

With these broad indications of a policy of prophylaxis based upon the host factor we may pass on to a closer analysis of the local sources of infection which will provide the key to the plan of campaign for the concentration of our forces against the more immediate dangers. But it is perhaps necessary to observe, both in regard to what has been said and what is to follow, that success will largely depend upon the local knowledge and on continuity of effort on the part of the medical staff to whom the work is committed. Frequent changes of the medical *personnel* are greatly to be deprecated ; and as regards the numerous expeditions that have marked the history of the last century, it has too often happened that medical officers have been drafted away to leave large cantonments inadequately served, the sanitation being the first of the responsibilities to suffer. This has doubtless been inevitable and the remedy is a larger reserve of officers for war, with an adequate peace establishment for all purposes which should be left intact on mobilization when perfect organisation is most necessary. If there be neglect at such times or a break in the sanitary service for any considerable period, the best methods and most assiduous care previously employed are largely thrown away.

We need not recapitulate *seriatim* the various sources and means of infection which were fully discussed in Chapter III. *et seq.* ; for our present purpose the main problem is to get into closest touch with them that we may attack them at their origin, and to this end we have to decide, in the first place, where the chief danger lies. Briefly, are we to look for this within or without cantonment limits,—to the immediate environment of the men themselves, or to the surroundings in which the native population supply the sources of infection? And if to both, can we discriminate between the extent of the danger inherent in each?

As regards cantonments can it be reaffirmed that they merit the estimation in which they have been held as "oases of purity in a desert of filth"? Is this, or is it not, a dangerous rhetorical fallacy based on the partial truth? It is submitted that there can be no possible doubt of the answer we must give to these questions in the light of the evidence before us. Enteric Fever is essentially a "filth" disease directly dependent on faulty conservancy, whereby the soil, the water and the air are subject to fæcal pollution, and to which young adults in aggregation are specially liable on first exposure to an alien environment, especially under the conditions of a primitive or improvised system of conservancy and water-supply. We have seen how we stand in regard to all these conditions and responsibilities: a steadily increasing number of men at the most susceptible age, renewed every year in larger proportion to the total strength; these in close aggregation, the danger of which is enhanced by common resort to latrines, lavatories, and hospitals, in refectories and dormitories, and by the prolonged occupation of certain sites under conditions which approximate to those of permanent camps; and with all this we have the evidence of a gradual rise in the prevalence of the disease in spite of all sanitary efforts put forth. The evil has stolen upon us unaware, and for long was entirely overlooked and denied; when recognized, it was only in the most typical and striking cases, and the conceptions of the etiology current in Europe under totally different conditions long governed the measures taken to meet it and were mostly confined to purely clinical treatment of cases in the advanced stages. There was no isolation of the sick, the roughest nursing and little if any attempt at disinfection; a large proportion of the infected were never detected and it was never suspected that the periods of greatest danger to the community were those preceding and following the disabling illness.

Such are the salient facts, the conditions thus set up gathering force by the vicious circle maintained by the multiplication and constant renewal of the sources of infection; the most serious results could only have been expected under the best ordered arrangements for the removal and disposal of excreta, the nidus of infection. But what are we to say of these arrangements ? Scarcely less than that they could not have been better devised and carried out to give every facility to the evil we deplore. A picture of the typical latrine and of the methods employed in disposal as they exist to-day has been given from the hand of one of the best and most unbiassed of authorities and endorsed by the Director-General of the Medical Department (Chapter III.). If further and fuller evidence be required it will be found in the following extract from the A.M.D. Report for 1904.

"Experience is daily proving that the method of treating excreta with dry earth and removing it in receptacles or carts for disposal in trenches is not only offensive and unsuitable but is also fraught with very real danger to the health of troops. The latrines are cumbrous structures with earthen floors and in not a few instances have been erected within ten yards of a cook-house. The seats are unprovided with covers, the pans are not protected from the ingress of flies, often do not fit sufficiently closely to the seat and so pollution of the ground with urine is frequently unavoidable. Dry earth is not, usually, immediately applied to the dejecta by the men and the pans frequently remain for some time unemptied by the sweepers. Soiling of the ground behind the latrine is not infrequent when the pans are being emptied into receptacles and is almost unavoidable when the latter are being emptied into the filth carts. The sweepers too have a practice of rinsing out the commode pan with water and throwing it over the ground, which contaminates it. The ground around the urinals and latrines in barracks is much the same and must get contaminated by men in the early stages of enteric before they report sick. At the urinals pollution of the earthen floor under the trough is common, and so is pollution of the ground outside the shelters when the urine receptacles are being emptied into the filth carts. We have now certain areas of ground, in and about latrines and urinals in barracks, which are always more or less polluted with possibly infected excreta, not to mention the pollution of the soil that occurs in the neighbourhood of barrack rooms, regimental institutes and canteens as a result of indiscriminate micturition by the men. Since it has been proved that the enteric bacillus can be recovered from Indian dust five days after it was infected and from the same after three days, when it had been exposed for nearly 24 hours to the rays of a tropical sun, it is quite evident what danger spots these polluted areas may prove when the blasts and whirls of the wind raise and carry away the infected upper layers of dust and deposit it on uncovered articles of food or even in the throats of human beings. But the risk of infection through this system of conservancy does not stop at the barracks. As the filth and receptacle carts rock along the roads some of their contents very frequently shake out, soiling both cart and ground. Efficient disinfection of the filth receptacles is not carried out at the trenches and they are often returned to cantonments in almost as dangerous a condition as when they left it. The filth carts can be neither properly emptied nor cleaned and they always carry back with them swarms of fæcal fed flies that forthwith proceed to distribute themselves about the barracks and officers' bungalows." (It should be noted that each battalion of Infantry is provided with no less than 23 latrines, to which these remarks apply in a greater or less degree.)

"The present method of disposal of excreta is also objectionable and insanitary. At some stations what is known as the Allahabad shallow trench system is in vogue. In this, the top soil is scraped off a rectangular space (16 feet × 5 feet) for a depth of three inches and the bottom soil is loosened for another six inches. Into this space the contents (60 gallons) of a filth cart are tipped, spread evenly over its bottom and then covered with the earth that had been removed. Heavy rain often washes the contents of these shallow trenches on to the surrounding ground. The tropical sun dries the covering of earth to the consistency of dust and the wind and flies carry the possibly infected excretal matters far and wide. No more dangerous system of disposal could be adopted in the vicinity of a cantonment, though it certainly works well on sites far removed from all habitations.

In some stations, however, excreta are disposed of in trenches one foot wide and nine inches deep, being deposited along the bottom to a depth of three inches and then covered in with earth. With this method the excreta is less likely to be exposed by rain and wind, but the trenches are still too shallow. Urine is deposited in separate trenches about six inches deep. At any trenching ground dogs, kites and crows may be observed scratching up the newly buried ordure in search of chance pieces of food, and the excretal matter thus exposed remains uncovered to dry and be converted into dust or carried away on the feet of flies. It is evident that shallow trenching affords every assistance to the spread of infectious disease. After a certain period (one to three months) at a suitable season the trenched ground is supposed to be cropped, but this is not always done, as it is often impossible from want of water."

The problem is to deal effectively with the discharges, alvine and urinary, of (1) recognized sufferers, (2) of those in the early and later stages of the disease, ambulants and convalescents, (3) of unrecognized cases that may never come under observation, and (4) of those whose systems are successfully resisting the infective agents,—it may be because these are few in number or lacking in virulence which, however, they may gradually attain. The indication is, surely, that the only safe plan is to treat the sewage of the whole community as if it contained the specific germ. It may be claimed that the general system of disposal now in vogue, *viz.*, by surface trenching, has much to recommend it both on scientific and practical grounds; the *rationale* of immediate earth disposal and the disadvantages of water-carriage are now sufficiently well understood and recognized, and we need not recapitulate the facts. But after all it is our business to apply our scientific knowledge with common sense to the circumstances of each case, and in this question far too little attention has been paid to the special conditions of the Indian soil and climate, to the infective qualities of the excreta, to the character of the community, to the resources at our disposal and to the methods employed. Tested by any one of these considerations we should find good reason to question the justification of the present practice, but in their combined force they bring it into condemnation that admits of no appeal, when applied everywhere without due regard to local conditions. Too often the sewage is deposited in soil on which it is impossible or difficult to raise a crop during the greater part of the year, and which is at one time exposed to sun and wind and so situated that clouds of infected dust are carried back to the cantonment; while, at other times, the monsoon deluge renders the trenching ground a swamp and scours the surface or carries pollution downwards to within the range of influence of the rising ground water. And this must often occur under the best ordered arrangements, but all the risks are multiplied by the ill-adapted resources for removal (the pail and cart system) and by the ignorant and careless practices of the native menial staff, *e.g.*, by the utilization of the infected soil of the trenching plot for the "dry earth" required in the latrines, and, as we have already seen, there are many other ways leading to failure of removal of the infective excreta from the site, or to their return from the place of deposit by foul carts, dust, flies and the persons of the staff and animals employed. There is always sufficient moisture in the soil at a depth of six inches to maintain the viability of the bacillus, which may well be favoured also by storage in the damp and shady annexe of the latrine, while at the same time, and under similar conditions, the more delicate cholera vibrio may find its quietus.

On the other hand, the evidence presented has demonstrated the extraordinary effect of light and intermittent rainfall in determining a break in the prevalence of the disease, the infective agents being thereby anchored to the soil by moisture and by the resulting vegetation. And these facts surely provide a clue to one solution of the problem, which will take account of all the risks encountered from the time and place of deposit in the latrines to the stage of final disposal: these indications are met by water-carriage, starting with an automatic flush to a properly adapted apparatus for mineralization by biological agency, and by final disposal of the effluent by irrigation and cultivation of suitable soil. But before discussing this in detail we may dwell further but briefly on the actual conditions set up by the present arrangements.

We have not far to look for abundant sources of specific infection in the inhabited site, centering in and radiating from latrines and trenching grounds, but which is scarcely free from pollution anywhere owing to the careless practice of urination in which the men indulge. It is easy to see how hospitals, barracks and kitchens are linked up with the more immediate foci, by means of traffic, dust and flies, the danger extending to the water-supplies in a measure depending on the circumstances of time and place. This is sufficiently indicated by the nature and extent of their micro-organic content, apart from the questionable isolation of the specific germ, and is brought about doubtless at one time by the access of polluted dust and flies, at another by the combined movements of the rainfall and the ground water.

Contributory factors in soil pollution and its results in favouring the viability and transport of the bacillus are the defective surface drainage, the lack of subsoil drainage and of arrangements for the effective disposal of sullage water, garbage and rubbish, and we have already seen how all these conditions co-operate to link up the chain of infections, and, in a word, to induce endemicity. Abundant confirmation is derived from the experience in regard to endemic Typhoid in all parts of the world ; we find Osler explaining that the provision of good water-supplies is not always sufficient to banish the disease from a community in the absence of effective drainage and removal of refuse, and that no fact is better established than the intimate association between a sewage-polluted soil and Enteric Fever ; while endemicity is due to persistent fæcal pollution of the soil. This writer also gives charts which demonstrate comparatively the enormous disadvantage in respect to the persistent prevalence of the disease which badly sewered communities suffer. Liebermeister says : "The disposition of any locality to Enteric depends largely on the extent to which the inhabitants breathe, eat or drink the contents of their privies ; the greater the chances of this, the greater the danger of an imported case producing an epidemic." The experience of the city of Munich in the great decline of the disease, subsequent to the abolition of the numerous cesspools from the site, is one of many cases in point ; and, again, the evidence of the definite association of the greatest incidence and of the endemic prevalence of the disease, on sections of a community dependent on privy middens, and similar arrangements for the retention of fæcal filth upon and within the site, is conclusively established. It is not only that the conditions thus set up provide a favourable nidus for the viability of the bacillus when introduced, but that they connote a radically defective conservancy in its widest sense which the best efforts in other directions fail to counteract; the first essential precaution is neglected, the predisposing conditions are ever present and constantly active, and every facility is provided for the dissemination of the virus. Long before the true etiology was elucidated by the efforts of bacteriologists, it was clear to acute observers that the secret of the suppression of the disease lay in the maintenance of a pure soil and surroundings, with the consequent prevention of pollution of the atmosphere and water in intimate relation therewith; and in pursuing the indications thus provided the greatest success has been achieved, *viz.*, by the abolition of cesspools and privy middens and the like, supplemented by drainage. (Buchanan, Boobyer, Pettenkofer, etc.). It may be admitted freely that the water-supplies have also been the objects of a vast amount of care and attention, but it must be maintained that this has been mainly effectual by obviating the risk of contact with the immediate sources of infection, by the removal of the latter; failing this, the purest water from outside will operate only to limit the extension of an outbreak. And it is to be noted that while the course of the disease among modern civilized communities has declined generally, but in the closer and more direct relation to improvements in conservancy, drainage and removal of refuse, than to improvements in the water-supply, where these measures can be distinguished in their operation, our public hygienic efforts as a whole have involved special dangers to the community in the provision of common sewerage and water-supplies with the risks of pollution of the latter by the former. The disease has, nevertheless, declined steadily; and as a further result its most striking manifestations are now afforded in its epidemic form which has coloured and distorted the etiological conceptions of observers, who would look to water-borne infection to explain all manifestations. The prejudice engendered by this experience, and fostered by school and text-book teaching in the West, has necessarily dominated opinion and practice in India, where the medical officers serve for a short term and are replaced by others. We see the results throughout the record in the constant endeavour to implicate the water-supplies in theory and in practice, and in the mass of contradictory evidence which is born of the assumption. This evidence has been reviewed at length (Chapter III.), and we have only been able to give it a qualified assent; where the sources of infection are so numerous and constantly present, water could not fail to play its part as a vehicle under the conditions to which it is subject, but it is submitted that this part is relatively subordinate when due regard is paid to the other avenues of infection. The futility of the efforts directed to the sterilization of the water in all cantonments during the last 8 or 10 years is a constant theme of despairing comment and of reproach; it is even contended by many, and not without reasonable grounds, that these efforts have added to the risks of pollution. We find officers enquiring pathetically whether, "if Enteric Fever be not usually water-borne we have not ourselves been unconscious agents in its dissemination by the very means taken to prevent it." "It seems unlikely that good measures enforced simultaneously throughout the cantonments in India should have everywhere been mismanaged and should, after years of efforts, have produced absolutely no good effect." "Either the measures were not of a kind to do good, or being good, they were not applied to the cause of the evil." (Sanitary Commissioner, India, 1897.)

And when we look to the usual sources of supply we can confidently pronounce them to be, in certain essential respects, beyond reproach, and it is only in the treatment to which we subject them that the danger lies. The essential default lies in the conversion of the soil in which the water stands into a reservoir for filth of all kinds which is largely infected with the specific germ, and beyond this, in the partial and often misdirected efforts to redeem the situation thus created: the use of multiple sources of varying degrees of purity for the same or for different purposes, with the risks of pollution at various points by the means adopted for drawing, distribution, "purification" and storage. The history of our efforts in these respects would afford a melancholy satire on good intentions misdirected, and on ingenuity perverted. We shall have a few remarks to offer later, on the practical application of the indications for obtaining and safeguarding a pure water-supply, but we may pass on now to note how the position described has diverted the true course of observation and fostered the theory of bazaar infection, which has held the field so long.

This brings us to a crucial issue in the problem, *viz.*, the relative importance of *intra-* and *extra-*cantonment sources of infection and the relation of the one to the other; and it is clear that a conclusive judgment is not only the necessary preliminary to practical measures, but that it must have the most direct and important influence on their nature and direction. The question is : Are we to look outside cantonments for the chief and omnipresent sources of infection, or are we to regard the men themselves and their immediate surroundings as the centres of the evil ? It is obvious that these views are irreconcileable, and that they vary diametrically in their logical indications. We have, at various points in the course of the discussion, endeavoured to indicate the bearing of the evidence on this question, and more particularly in Chapter VII., to which the reader is referred, and we shall abstain from drawing any inference from the facts and opinions presented in Chapters VIII. and IX. One consideration must be constantly borne in mind even when the evidence of bazaar or outside infection is most incontrovertible, and that is the possibility, the probability, of its indirect derivation from a previous case which had its origin within cantonments. In so far as bazaars and other outside resorts are, to all intents and purposes, adjuncts and extensions of the cantonments, where sanitary appliances and precautions are either totally lacking or less under control, it is only to be expected that they should be centres of infection which are set up in the same way as those in cantonments, *i.e.*, by the men themselves ; there is certainly no need to postulate an indigenous origin of the infection.

Then let the evidence as set forth on all aspects of the subject be tested by the alternatives : the changes in the constitution of the *personnel* ; the course, rise and decline of the disease during the 35 years of the record, with the evidence of a real increase and of its original absence in certain localities where it has since become endemic—and this taken along with the marked decline in the prevalence of other indigenous infections to which the native population is notoriously susceptible ; the history of importation, most strikingly illustrated in connexion with the Boer prisoners of war, but established as constantly derived from forces in the field and transported from one cantonment to another, of which the experience of the Hill stations affords the clearest example ; the evidence from camps and campaigns ; the characteristic features of the local and seasonal incidence ; and, lastly, the indications derived from our study of the incidence on the different arms and classes (officers, women and children, separately, and when compared *inter se* and with the rank and file) and from the closer analysis of corps unit and company infections. And in forming a judgment on this issue due regard must be paid to the evidence derived from the experience of the disease in other countries, where the question of the "saturation of the Natives with Enteric Fever" does not arise ; and we may point to the history of the mobilization camps in America in 1898 as specially pertinent.

There is one additional consideration which deserves more than a passing allusion. Medical Officers have found support for the theory of bazaar infection in the fact that men admitted to hospital for Venereal disease have frequently developed Enteric Fever, and as there can be no doubt of the place of origin of the one affection, it is plausible, *primâ facie,* to connect the other therewith.

Now, in the first place, it must be noted that all the circumstances render the men under 25 years of age and those in the earlier period of their service specially liable to both affections, and the test thus presented may be deemed peculiarly valid and conclusive, so far as the facts are to be relied on. It is, however, overlooked that fully one-third of the total admissions for all causes is due to Venereal disease, and the proportion to the total at the most susceptible age for Enteric Fever must be much higher ; during the quinquennium ending 1899, the average number of men constantly in hospital on this account (Venereal) was 2,880, and the average period of detention for each case was 32·5 days, while the average number constantly sick from *all* other causes was 3,445. This shows clearly that an enormous proportion of the most susceptible subjects is exposed to risk in the bazaars,—and also in the hospitals. It is, therefore, only to be expected that when, probably, two-thirds of the younger men pass four and a half weeks in hospital every year for Venereal disease a considerable number should develope the other infection in the course of their detention ; and this without taking into account the risks of infection in hospital, and the fact that the incubation period does not often exceed 10 to 14 days, and may be less. Of 301 cases noted as developing in hospital during ten years (1891-1900), 108 occurred among patients admitted for Venereal disease, 102 among other patients, and 91 among attendants, and it is submitted that in view of the foregoing facts and considerations, this does not disclose any excessive proportional liability on Venereal patients beyond that due to age and early service ; it may be added that such patients are only rarely confined to bed and most of them "have the run" of the hospital and may even attend on Enteric cases, though doubtless this is not sanctioned. Even if it could be demonstrated that the Enteric infection in these cases was actually derived from the bazaar along with the Venereal infection, we should still leave the question of the original source of the infection in doubt, but it is certain that ambulant and early cases of the disease and convalescents must contribute largely to its dissemination in the brothels and the bazaar haunts where sanitary arrangements and all prudential considerations are equally lacking.

Now both Enteric Fever and Venereal disease increased, *pari passu*, to their maximum prevalence in the year 1898, which might, again, be taken by the casual observer to indicate a common origin in place and time, but when we examine the respective geographical and seasonal incidence of the two affections, the most definite contrasts are exhibited, thus:—

INCIDENCE OF ENTERIC FEVER AND VENEREAL DISEASES ON THE DIFFERENT GEOGRAPHICAL GROUPS.

Admissions per 1000 *of strength*, 1891—1900.

ENTERIC FEVER.		VENEREAL DISEASES.	
Groups.	Ratio per mille.	Groups.	Ratio per mille.
1. Hill Stations (XII a) ...	33·8	1. Gangetic Plain (V)	539
2. S. E. Rajputana and Central India (VIII) ...	32·2	2. S. E. Rajputana and Central India (VIII) ...	504
3. Gangetic Plain (V)	30·2	3. Burma Coast (I)	496
4. Upper Sub Himalaya (VI) ..	27·0	4. Deccan (IX)	484
5. Deccan (IX)	21·5	5. Burma Inland (II)	481
6. N.-W. Frontier, Indus Valley (VII)	19·5	6. Southern India (XI)	458
7. Southern India (XI)	16·9	7. Bengal-Orissa (IV)	447
8. Hill Convalescent Depôts (XII b)	15·8	8. Upper Sub-Himalaya (VI) ...	428
9. Bengal-Orissa (IV)	11·1	9. Western Coast (X)	426
10. Burma Coast (I)	8·4	10. Hill Stations (XII a)	355
11. Western Coast (X)	7·3	11. „ Convalescent Depôts (XII b)	351
12. Burma Inland (II)	4·7	12. N.-W. Frontier, Indus Valley (VII)	316
INDIA	24·2	INDIA	431

In the period 1901-03 the order of prevalence among the Groups was as follows, from greatest to least:

Enteric ... VIII, VI, V, IX, XII a, XII b, VII, XI, IV, II, I, X.
Venereal ... I, IV, IX, XI, VIII, II, X, V, VI, XII b, VII, XII a.

If we analyse next the incidence on the various cantonments the contrast is brought out still more forcibly. Space is not available to give lists comparing the places in which the two infections were respectively most prevalent, but it will be found that whereas Venereal disease gives the highest ratios in the stations which are situated in the peninsular (Southern) and coast areas, including the sea-ports, Enteric Fever is at its maximum in the continental (Northern) and inland regions.

The following statement will, however, exhibit the main facts in a condensed form; it shows the distribution by Commands of the thirty stations which stood highest on the lists for Enteric Fever and Venereal diseases during the four years 1900-03, the total number of cantonments, with an average strength of over 100 men, being 95:—

Command.	No. of stations altogether in Command.	Enteric Fever. Distribution of the 30 stations highest on list 1900-03.	Venereal Disease. Distribution of 30 stations standing highest on list 1900-03.
Bengal ...	31 (124)	46	34
Punjab ...	27 (108)	38	7
Madras & Burma ...	18 (72)	7	39
Bombay ...	19 (76)	29	40
Total ...	95 (380)	120	120

NOTE.—The figures in brackets represent the number of stations exposed during the four years.

We need offer no comment on these facts, for it is clear that there is rather an inverse than a direct relation between the endemic foci of the two diseases. But we may emphasize the conclusion by glancing at the relative incidence on corps units in 1903 for which the records are available. We take the 20 regiments standing highest on the Venereal list, with ratios of admissions ranging from 302 to 885 *per mille* of strength, and for comparison the 20 corps at the bottom of the Venereal list, the range being from 75 to 230 *per mille*. Of the former series no less than 8 were newly arrived regiments, *i.e.*, they had landed in India during the last trooping season, 1902-03, or subsequently, while of the latter series only six regiments were in like case, and 11 had been over five years in the country. Nevertheless, the incidence of Enteric Fever was 50 *per cent* higher on the latter body of men than on the former, *i.e.*, for the 20 corps with the enormous Venereal ratios, the Enteric rate was 15·1 *per mille*, against 22·8 *per mille* for the corps with less than half the amount of Venereal disease.

Lastly as regards the seasonal incidence, it will suffice to say that the period of greatest prevalence of Enteric Fever, *viz.*, April to September, is precisely that when the admissions for Venereal disease fall to the minimum, though it is true that the month of April shows a comparatively high number for the latter affections. Forty *per cent* of the total Venereal sickness is returned during the first four months of the year (33 *per cent* of time), a gradual increment being observed from the onset of the cold weather (October), due probably to the arrival of drafts and reliefs and to the greater vigour and activity of the men during the winter.

We have quoted the results of an enquiry into the prevalence of Venereal disease which showed that 71 *per cent* of the force present in 1894 had been admitted to hospital on this account since the arrival of the men in India : this certainly indicates that very few—a negligible minority—avoid the risks of bazaar infection to the fullest extent to which they prevail. The facts set forth, however, are not to be reconciled with the easy assumption of widespread sources of infection in the bazaars and other extra-cantonment resorts to which the prime and chief danger may be traced, but, on the contrary, they lend a special force to the contention that, in so far as these sources exist, they are derived from the men themselves. And for the rest it may be affirmed that scarcely one prominent feature of the epidemiology requires the invocation of external sources of infection, while, on the other hand, the various problems are at once elucidated when we regard the soldier and his immediate surroundings as the *fons et origo mali*. This is not to deny the necessity of all measures of sanitary amelioration that can be applied to these resorts, if only on the ground that they are *de facto* extensions of the cantonment, but it is obvious that our charity must begin at home—that we must set our own house in order—that the problem must be attacked at its root, whereas, hitherto we have sown the noxious tree and exhausted energy in lopping its branches.

Having now seen how we stand in regard to our obligations, we are face to face with the question of the essential features of a policy of reform. The remarks which follow must be taken merely as suggestions with a wide general application and as representing the results of individual cogitation which claims no special authority ; the conditions of each community and locality must necessarily be studied by those primarily responsible and the measures must be adapted thereto. Our object may be said, in the words of Simon, to be "the perfect adaptation of drainage, water-supply and scavenage to the purpose of carrying away, inoffensively, all refuse materials of life from the person, the house and the environment so soon as possible after their formation, and with as near an approach as possible to one continuous current of removal", and with this, their speedy, safe and economical disposal. The subject claims a few observations under the following heads : (1) removal of excreta and polluted waste water ; (2) disposal ; (3) water-supplies ; (4) general remarks on the hygiene of the soldier and his surroundings.

In regard to the first two questions, the writer desires to urge the claims of the water-carriage system of removal with subsequent disposal by what are well-known as "biological" methods, the *rationale* of which and their adaptability to cantonment conditions in India were discussed by him in a contribution to the "*Scientific Memoirs by Medical Officers of the Army of India*," Part XII, 1901.

The objections that have been raised in this country against the more artificial biological methods, and which at present appear to stand in the way of their adoption, are—

"Want of more extended experience of the system ; the necessity for an abundant and cheap supply of water for purposes of dilution."*

The doubt as to the passage through the apparatus of pathogenic germs.

Difficulties in the way of water-carriage due to the character of the site ; and the prime cost.

* See letter of Quarter Master General to L. G. Cs. of 29th June, 1900.

As regards the first, it may be said that experiments already made in India have put the question beyond doubt, as far as the main issue is concerned, even if details vary and require elaboration in minor points (see reports from Bombay, Poona, Calcutta, Simla and elsewhere.) Experiments in India have fully demonstrated the capacity of the biological methods to deal with the excrement of natives which averages 10 oz. for each person, with all its undigested food residue and large excess of cellulose, with a dilution of 4* gallons per head, and it is certain that the European adult average excrement of 5 oz. could be submitted to the process with equally good results when diluted with 3 gallons of water, because of the relative diminution in quantity and of the comparative absence of undigested residues.

Does the European soldier receive, for ablutionary and culinary purposes, less than 3 gallons of water per diem ? If he does, the difficulty of supplementing the supply to reach this amount is surely not insuperable ; but is it too much to ask that this amount of fresh water should be set aside for the purpose of diluting the excreta ? One of the objections raised against trenching-grounds is the lack of irrigation water for cultivation ; the intermittent bestowal of a "purified" effluent from a "biological" installation not only returns the necessary nitrogen to the soil for manurial purposes for raising crops of vegetables, but it brings at the same time the required supply of moisture, while it relieves the inhabited site of so much stagnant waste.

As for the second objection, there is certainly no intention on the writer's part to minimise its importance, but, first, it must be noted that it is hypothetic and inferential. If pathogenic germs be contained in the solid and liquid excreta—and it may be taken as certain that they do—what are we to say of the present arrangements ? The fact forms the most damning indictment of these arrangements, and one might be content to rest the case for the prosecution on this alone. Given a damp polluted soil upon which contaminated fæces and urine are constantly deposited, and add to this the faulty latrine system, and we have abundant foci of infection provided before we get to the trenching-ground. Let us, however, look at what we actually know as regards the biological methods of which an adequate system of *removal* must form an integral part. It is proved to demonstration that where a proper water closet and drainage system is in use, there Enteric Fever

* Three gallons in some of the Calcutta experiments.

is enormously reduced, if not altogether abolished. (Boobyer, Osler; Bermuda; American Camps.) We may, however, admit that while the chemical qualities of a sewage effluent can be controlled by biological methods to any extent and to any desired standard, yet the evidence, so far available, appears to point to the fact that in some forms which these methods take, there is no large detention or destruction of the characteristic flora of sewage. Organisms, not indeed ranked as pathogenic, if highly suspect—*e.g.*, *B. coli*,—are found in practically the same abundance in a chemically pure effluent as in the original raw sewage, after passage through downward filtration beds, or after "contact" in aërating "filters." (Clowes and Houston; L. C. C. Reports.) The importance of this fact is not to be underestimated, but it may be pointed out that the prospects of those methods which include an anaërobic stage are manifestly brighter than those which rely on "aëration" pure and simple, and for these reasons. The pathogenic organisms of water-borne diseases are aërobes even if we allow them a facultative existence where free oxygen is at a minimum; they are by far the most fastidious and the least robust in the struggle for life when confined under the conditions which obtain in a septic tank or bed, which is swarming with anaërobes, and with saprophytic and putrefactive rivals. We know that even among these latter the tide of victory rises and falls, with the extermination of the least fit at each stage of the battle, and these are favoured by all the conditions of a natural habitat. It must go much harder with a *parasite* and an aërobe; the absence of free oxygen, the conditions of temperature and the fluctuations in reaction are inimical to fastidious parasites, even if they had the field to themselves. The "germs" of typhoid and cholera are particularly fastidious in these respects, and it is probable that both lose infective virulence during their passage through the human organism which they only regain after exposure to air; and as they are believed not to form spores, they are deprived of their best chance of survival until the conditions become more favourable. It is not strange, on the contrary that *B. coli* and *B. enteriditis sporogenes*, which are universally present in the environment, and which are normal habitants of the intestinal tract where putrefactive processes are initiated under anaërobic conditions, should find the conditions more propitious.

What we can say amounts to this, that the sojourn of fastidious parasites in an anaërobic tank exposes them to such unfavourable conditions, mechanical, (from sedimentation and a course of upward and downward filtration), chemical and biological, that the chances of ultimate survival in the final effluent are exceedingly poor and doubtful. The fate of pathogenic organisms in the dead animal body under anaërobic conditions affords striking testimony in favour of this view. (Klein. L.G.B. Report, 1898-99). These are some of the first general considerations which, indeed, are far from conclusive, but the results of more recent experiments directed to a solution of the question go far to justify confidence in the ultimate results.

The Committee recently appointed by the Government of Bengal to study the question of the purification of the septic tank effluents from certain installations provided for the large mills on the banks of the Hooghly have reported remarkable results from the use of chlorinated lime (33 *per cent* of available chlorine). It has been found that when this substance is mixed with the effluent in the proportion of 5 grains to the gallon, the latter is rendered virtually sterile and certainly much purer (bacteriologically) than the filtered drinking-water of Calcutta. Repeated examinations, confirmed independently, failed to demonstrate the presence of *b. coli* or of *b. enteritidis* in cultures made from the effluent after this lime treatment, the cost of which does not exceed Rs. 10—15 a month, for an installation adapted to deal with the excreta of 2,000 persons. The bactericidal action is, moreover, complete within the first hour. It may be well to add that the installations in these cases (*i.e.* for Natives) are arranged in the form of a series of latrines (W. Cs.) on the top of the septic tank and that a flush of 4 gallons of water (actuated by pedals) is provided for each user, the excreta being washed at once into the tank. The water, raised by pump, is stored on the roof; the capacity of the septic tank is arranged to accommodate from $2\frac{1}{2}$ to 3 days' sewage, and the resulting effluent even before passing into the aeration beds must be described as very good. One example is given in the margin.

Kanchrapara Latrine.

		Parts per 100,000
Chlorine	...	2·41
Free Ammonia	...	1·275
Albuminoid Do.	...	·19
Nitrates	...	·07
O. absorbed (10 minutes)	...	·6
Do. (4 hours)	...	1·06

Into the details and technique of disposal by "biological" methods we do not propose to enter; the system has emerged successfully from the stage of probation both in England and India, and every scheme must receive separate consideration by Medical Officers and Engineers qualified for the work, the main lines of which have now been sufficiently established. We shall merely affirm as the result of personal practical experience, that, in view of the comparatively concentrated nature of the sewage owing to the low measure of dilution ordinarily available, installations must be constructed for the double process of preliminary hydrolysis and subsequent aeration, *i. e.*, for a septic tank or upward "filtration" followed by a passage of the first effluent through porous beds arranged for intermittent "contact" or downward filtration. The measure of concentration of the sewage will determine the required capacity of the former to ensure full hydrolysis by the necessary length of sojourn in the tank, the capacity of the filters being adjusted to accommodate the actual amount of the effluent.

But it may be said that for a body of 1,000 Europeans with a water-supply of 3 gals. per head, a septic tank of the capacity 6,000 to 9,000 gals. would be required, according as a 2 or 3 days' sojourn of the sewage in the tank be found necessary; probably the former period would be ample. This involves 960 cubic feet of space and as the most suitable depth is 6 feet the other dimensions of the tank would be 8 feet by 20 feet. The subsequent process of aeration would require arrangements for a charge of 4,000 gals. daily (allowing for alternation in use and the rest of one "filter" at intervals) and for this, 4 beds, each of 280 cubic feet capacity, would suffice, after the introduction of the filtering material. If the results of the lime treatment be substantiated, one of the gravest difficulties, *viz.*, that of removal of the sewage from the site to the installation at an inconvenient distance, where the gradients are inadequate, will be largely obviated. And when the effluent is disposed of on light, porous soil which should be systematically cultivated, it will be admitted that the possible danger bears an altogether insignificant proportion to that incurred in the methods at present in use.

The apparently insuperable difficulty of obtaining adequate supervision, absolutely essential for carrying out trenching, is minimised, and with a proper integral system of removal, is almost entirely obviated, while the risks to health, to some extent incumbent on all methods, are largely discounted. In larger communities installations can be established at suitable points, and so save the cost of costly schemes for the devolution of all the sewage to a common outfall; smaller communities need not wait for the comprehensive schemes required by towns in or near which they are situated. As regards the final disposal of the effluent, the question of its discharge into a stream or natural drainage channel, will rarely arise in the cantonment problem, for it is to be remembered that in the endemic area of Enteric Fever, the conditions of soil and climate are such as to require moisture by irrigation for 8 or 9 months of the year ; the effluent is entirely absorbed or evaporated, and no question of its final disposal, or of deep drainage, arises. A few suggestions may now be offered on the practical aspects.

Removal.—It will be seen that the key to the situation is the prompt and complete removal of refuse, with as near an approach as possible to automatic action to the place of "purification," whereby we obviate pollution of the soil of the site and of the water-supplies ; given a successful solution of the first problem, the other results naturally follow, though certain additional precautions will be indicated as regards the water-supply from wells.

The first essential is the total abolition of the present latrine system, with the filth-sodden floors and sites, the retention of filth, the "dry-earth" nuisance, the multiple manipulations from receptacle to pail and from pail to filth-cart, and the unscrupulous *mehter.* We must treat each barrack as a unit in the scheme and utilize the waste water, which at present is not properly disposed of, as our motive power for immediate removal, while at the same time we secure its safe disposal. How are we to effect this ? The means and the circumstances will vary, but a little judgment and engineering skill will, in most cases, solve the problem. In the case of hill cantonments we shall have no difficulty, as we may take full advantage of the site and gravitation. The ablution water and other waste can be run from the barracks to detached water-closet latrines on a lower level, where a flush is secured and the excremental refuse will be carried automatically to the biological installation at a lower level, and the effluent be conducted thence by pipes to the arable land. These considerations provide an additional inducement to carry out the policy recommended of a completer utilization of Hill sites for the cantonment of troops on first arrival in India, and for the retention thereon of all the younger men during the first two years of their sojourn.

In the Plains difficulties in regard to the necessary gradients must often be encountered ; a great deal obviously depends on the natural levels of the site ; in some cases it may be said that the whole arrangement is a plumber's job ; where gradients are less favourable, we shall have to resort to expedients to overcome the difficulties. The first consideration is, then, the survey of the ground of the cantonment, to indicate the most favourable levels ; on the one side between the latrine and lavatory sites and the biological installation, and on the other side, between the latter and the ground to which the effluent is to flow for final disposal. This indeed is the crux of the problem of perfectly efficient removal, and it is one that must receive the most careful attention in the first place. Much will depend on the arrangement of the barracks and their affiliated latrines and lavatories on the site, *i. e.*, whether in extended line or whether in square or parallelogram, as regards the most economical laying of the latrine drain pipes and their linking up into a larger connecting drain which will conduct to the installation ; but given a sufficient natural fall in the ground this is a matter of detail presenting little or no difficulty.

Take the case of the ordinary company-barrack, to each of which is attached, ordinarily, two latrines and a lavatory. The present pan arrangements of the former should be dismantled ; the flooring within, and the soil around, the latrine should be removed, renewed and asphalted and the whole site and structure be thoroughly disinfected. It should then be fitted with automatic flush W. C's. which should be raised to a sufficient height above the floor level to provide an adequate fall for the soil pipe which should run from end to end of the latrine, receiving the discharges of the series of W. C's., to convey them to the connecting drain. If, for example, the closets are raised some 4 feet above ground-level, we at once secure a gradient of 1 in 30 for the first 40 yards of the system, that is, until the connecting drain is reached, which may therefore take-off at surface level and still have the whole of the natural gradient available.

For the supply of flushing water two sources are available, *viz.*, that from the lavatory and the swimming bath and a separate supply of fresh water, which would only amount to some 300-350 gallons per company, and which, as in the present case of the lavatories, would have to be conveyed by pump to a reservoir placed at a higher level (7 or 8 feet) than the W. C.'s ; if water can be conveyed to a tank in the lavatories, there can surely be no difficulty about the latrine supply. With this separate supply of 3 gallons per head for the W. C.'s, the whole of the lavatory and bath waste could be utilized for flushing purposes, by being conducted to a siphon flush tank discharging at the head of the main drain, or at proper intervals along its course, according to the circumstances of the site and the arrangement of the main drains, the flushing tanks being of from 100 to 300-gallon capacity according to the length of sewer to be flushed. In regard to the arrangement and course of the main drain everything will depend upon the number and position of the W. C. latrines to be connected and upon the natural gradients to be obtained. It is believed that, in general, a fall all over of 1 in 100,—or 15 feet in the course of 500 yards,—will be ample to ensure self-cleansing with the flushing arrangements as suggested. The kitchen waste-water should of course be diverted to the drain at the nearest convenient point. If the necessary gradient be not naturally available, it may be increased easily by depressing the "biological" tank below ground level to the required extent. The effluent would be discharged into a tank from which it would be necessary to raise it by means of an ordinary Persian wheel worked by a bullock, or by a pump, in order to provide the requisite fall to the ground set apart for irrigation.

To recommend such a system of removal may be deemed a counsel of perfection, but it is surely feasible in many, if not all, of the cantonments, and half-hearted and partial methods in dealing with a situation which is the legacy of forty years of failure and compromise will be found far more costly in the long run. A proposal recently sanctioned to try the effects of special measures of disinfection in latrines will cost at least £100 *per annum* in the case of each regiment, a sum which may be taken to represent the interest on a capital of £3,300, and without discounting the results, one may fairly assume that financial considerations can scarcely be urged in favour of the present policy. Enough has been said to make it clear that the present latrine system and the methods employed in the removal of the excreta are the essential, the prime and the chief sources of the evil, compared with which all other factors are secondary and on which other factors are dependant; compromise in the way of efforts directed against the latter are foredoomed to failure. In one way or another the solution of the problem should not be beyond our resources: if an organic drainage system be found impracticable we must turn to some modification, such as W. C. latrines with automatic flush, the soil-pipe of which will be adjusted by screw joint at some distance to a sealed car tank with non-absorbent lining, which will retain the excreta of a day or more and then be run on well-laid tram-lines to a "biological" installation where it would be thoroughly flushed out; its place while in transit would be taken immediately by a similar tank. We may also refer incidentally to the Neilson system of disposal by cesspool tanks, which are reported to have yielded very good results in the City of Florence, (see *Lancet*, May 20th, 1905, p. 1373).

Considering the great danger arising from the long-continued infectiveness of urine in Enteric Fever cases and convalescents, the present arrangements for urinaries demand attention. These are lightly built and cheap structures, the abandonment of which would not involve much monetary loss; on the other hand, the immediate and complete removal of this, perhaps the most dangerous of the excreta, would be a great gain. The precise details are a matter for consideration, and present no great difficulties, provided it be conceded that a W. C. and drainage system are essential to adequate sanitation. Some forms of flush W. C.'s can be used as urinaries; in other cases, it is merely a question of providing non-absorbent receptacles or channels at the top end of the latrine and arranging for an occasional flush from the latrine tank; or the urinary might be placed next to the lavatory, the waste of which, on its passage to the automatic flush tank at the head of the drain, could be directed to flush the urinary.

As regards urinaries for night use in barracks, the arrangements should include a receptacle for the ground floor, instead of as formerly for the upper stories only. Men in the former will utilize the nearest open ground, at night, instead of resorting to the urinary. These barrack conveniences should properly be connected with the nearest latrine drain, although it may be admitted that there are difficulties in providing the necessary flushing; but if water be laid on to the barracks, as it should be, these would not prove insuperable. Leaving flush tanks out of the question, a pail of water discharged into each receptacle every morning would serve the purpose.

In connexion with the automatic arrangements for flushing the W. C. pans, it would certainly be well if the British soldier could be induced to adopt the physiological attitude in defæcation, *i.e.* squatting. This would involve far less danger from contact of body and clothes with the structure of the latrine and it would secure a completer evacuation of the bowels. It should be noted that intestinal hernia is just four times more frequent among European troops than among Native troops and prisoners.

The case for improving the conditions of the removal and disposal of the excreta of Native troops, is little less urgent, where Europeans and Natives are cantoned together. Difficulties there are in the way of a perfect scheme which one need scarcely anticipate in the case of European troops, and especially in the supply of the necessary water for dilution and removal. But at the same time the whole problem is simplified, if we abandon the system of removal by drainage, which alone necessitates a fairly large supply of water as the motive power. If natives can be compelled to walk (as they now do to the trenching grounds) to the site of an installation, two or more being provided at suitable points to divide up the distance to be traversed, it would appear from experiments that a dilution of the excreta with two gallons in excess of the ablution water in customary use, would be perfectly adequately transformed in an apparatus, the first upward bed or septic tank of which was sufficiently large to secure the retention of each day's sewage for some 4 to 6 days, and this is only providing structurally for a daily quantity of excreta with a dilution per head of 4 to 6 gallons. Here we should escape the drainage difficulties with the flushing requirements, and the men would deposit their excreta in a flush latrine above the septic tank, and water to the extent of two gallons per head could be provided in the latrine flush. This would entirely meet the water difficulty, and involve no more expense in construction, as although the septic tank would have to be slightly larger, to ensure a due sojourn therein for thorough hydrolysis, it would be more than compensated by the decrease in the size of the subsequent downward filtration area, which would only need to accommodate a body of sewage made up of about 2½ gallons per head. The sewage of a bazaar affiliated to a cantonment could be dealt with in the same manner.

Water-supply.—A few remarks may next be offered in regard to the water-supply. Given an unpolluted soil, there is probably no safer nor more economical source than the ground water tapped by means of properly protected wells. There is abundant evidence of the dangers to which gravitation supplies from rivers, tanks and surface wells and springs are open.

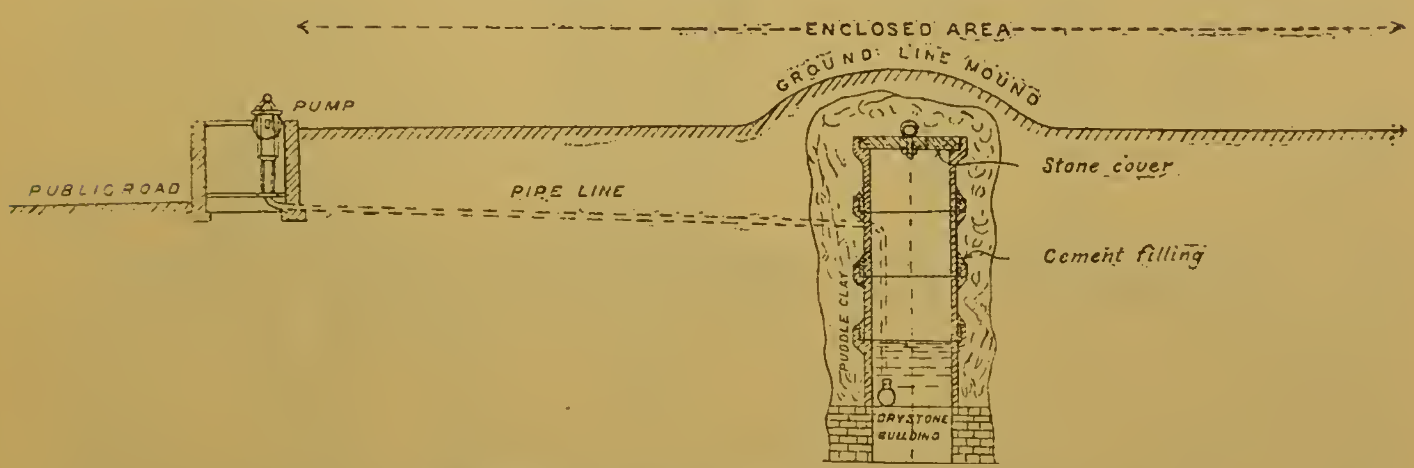
and no filtration process of a polluted supply can be held to justify its use save under exceptional circumstances, of which the most valid is that there is no choice.* Wells must be chosen or made, with due regard to the surroundings and the natural flow of the ground-water, and after adequate protection in their course through the soil, they should be provided with pump-tubes and hermetically sealed by masonry covers ; the tube should be conducted through the lining below the parapet to some distance from the well mouth, where it will join the pump, so that no pumping is done over the well mouth. The ground around the well should be laid out in grass and the whole area fenced-off to obviate all access by man or beast. A force-pump should be used to raise the water to a proper covered receptacle at a height sufficient to give a fall to the barrack, hospital and kitchen, where it should be accessible by means of brass taps on the verandahs ; the pipes must not stop short of the points of consumption. The chief points to be observed are the choice of the well in unpolluted ground ; the protection of the well both as regards its lining and its cover, which latter *must* be dust and water proof ; the reservation of the area around, and the provision of the pump outside the reservation; the complete distribution by pipes to the barracks, hospital, etc. We have not dealt fairly with our wells in India ; we cannot expect pure water from a high and fluctuating ground water, which washes a polluted soil and which is often tapped in ground below the level of a neighbouring native village or bazaar. Beyond this, we find a good well often fails to yield a sufficient quantity in the dry months, and is condemned as useless, when deeper boring would tap the permanent supply, and not the fluctuating "drainage" level. In view of the considerations adduced in a former chapter as to the retentive properties of clay for all foul organic matters and their concomitants, no question is of more practical importance than that of deep boring in order to avoid the polluted water near the surface which is retained *in situ* by a comparatively superficial stratum of clay which, at the same time, protects the water in the sand and gravel beneath it. The indication is therefore plain, *viz.* to take advantage of the first clay stratum by tapping the water at the lower level, and fortunately, this

* See remarks by the Bacteriologist, North Western Provinces and Oudh, as to the relative purity of filtered river-water and the supply from wells at Agra.—Report of Sanitary Commissioner (India) for 1899, p. 49 ; also Dr. Thresh on the safety of rural well-water-supplies, *Lancet*, April 15, 1905.

can be done, in many cases by a simple expedient applied to the wells at present in use.

An iron pipe, 3 or 4 inches in diameter, may be sunk through the bottom of the well, as in ordinary boring, until the supply of purer water, below the clay, is struck, and this water will rise into the well in ample quantity. But, at the same time, the bottom of the well must be plugged with a floor of masonry in concrete to prevent the access of the water from the upper layers of the soil. A narrow cylinder of larger diameter may replace the iron pipe where larger quantities of

DIAGRAM No. XXVI.



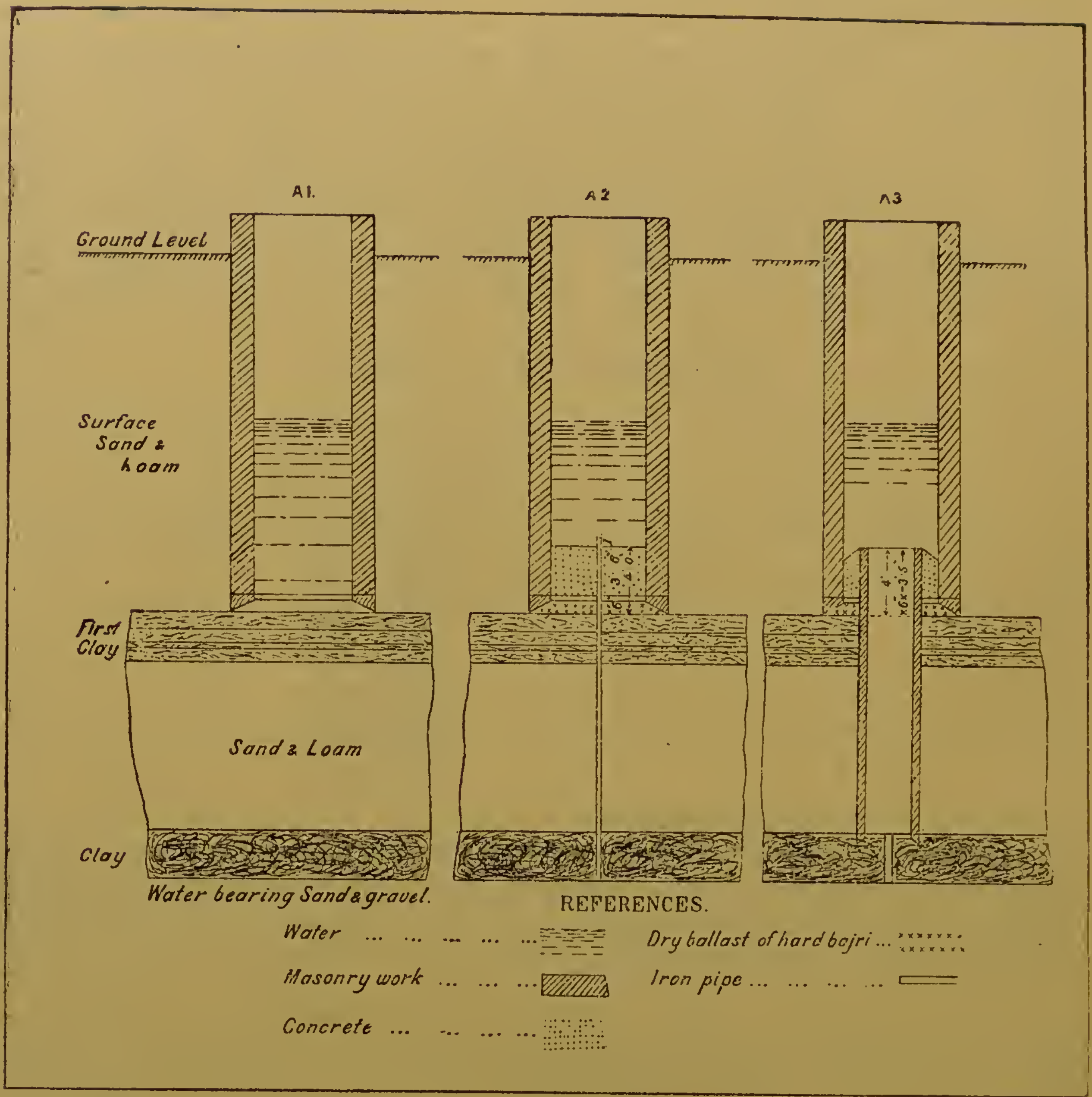
Scale 8 *Ft.* = *1 Inch.*

A safe form of well, devised and used by R. W. D. MacMartin Cameron, M.D., D.SC., Medical Officer of Health for the County Councils of Kircudbright and Wigtown. The arrangement and the advantages are equally obvious. The reserved area should be at least 20 yards in diameter, with the well in the centre; but this area may certainly be increased largely, if deemed necessary, to ¼ or even ½ an acre. The lead pipe running from well to pump should be fitted to the latter by brass screw joining.

water are required. The accompanying diagrams will give a clearer indication of the position, which is frequently found in the plains of Upper India, and of the methods suggested; they are taken with slight alteration from Bulletin No. 20 of the Department of Land Records and Agriculture of the United Provinces, the author being Mr. Moreland, C.I.E., the Director. A 1 shows an ordinary well-cylinder resting on the first clay layer and drawing its water thence; A 2 and A 3 the same well altered by provision of bore pipe and inner cylinder respectively. (See next page.)

By such simple measures, the necessary quantity of water may be obtained, as to the quality of which there need be little doubt; and for the rest, all unnecessary interference and manipulation should be scrupulously interdicted and indeed obviated by abolishing the various risks in the chain of supply by human agency, any one of which may introduce pollution

DIAGRAM No. XXVII.



Slightly altered from Bulletin No. 20, Dept. Land Records, United Provinces. (Mr. Moreland, C. I. E.)

Systematic bacterioscopic examinations of the water should be instituted at all centres, and these should include comparative observations in regard to the normal or predominant flora of the soil of the drainage areas of the wells. Such observations carried on in a large number of places, differing in their geological and climatological characteristics, throughout the seasons and for a sufficient time, would, if supplemented by exact meteorological observations, be of immense value. The epidemiology of many diseases would doubtless be elucidated; as it is, our knowledge of the seasonal variations of the bacterial flora of soil and water is very defective. If, however, the precautions we have indicated are maintained, we need have no fear of direct or indirect contamination of the wells. But, however good the sources, we cannot expect to secure safety if they are open to pollution by dust or by the methods still in vogue in many places for drawing, distributing and storing the water by hand in all sorts of receptacles; the whole procedure involves a series of risky compromises, one directed to nullify the results of another, and our efforts themselves contribute to our defeat. Again, where the methods in use are better calculated to fulfil the requirements laid down, they are too often partial and stop short of systematic completeness at one point or another; this involves the dangers of multiple sources of varying degrees of purity, of storage to complete the chain of supply and of reliance on faulty measures of purification.

Aerated waters are consumed in large quantities and the authorities are fully alive to the necessity for scrupulous care in all details of their preparation; here the use of the Pasteur-Chamberland filter is amply justified with the supervision that can be given to prevent abuse. It would be a good investment to provide a liberal supply of these waters from regimental factories free of charge, and in every cantonment bazaar a branch of the regimental institute should be established for the provision of simple refreshments. Special care should of course be exercised to ensure a supply of good water at rifle ranges and wherever the men are called on extra-cantonment duty.

In regard to other measures of conservancy, we need only refer to the necessity of the complete and expeditious removal and destruction of all garbage, manure and refuse of every description, which replenish the soil with organic matter and favour the breeding of flies; incineration, which may provide steam power for pumping or other purposes, is clearly indicated. The prompt disposal of kitchen waste and sullage is equally important and has been referred to in connection with the sewage arrangements.

It is open to question whether measures are practicable for the suppression of the dust nuisance in this country, but it should be possible to minimise its worst effects by providing screens to the barrack verandahs and venetian blinds to the upper story windows. Paving of the site around barracks and latrines and the cultivation of trees and grass are measures which demand consideration. The danger that is incurred from dust in riding schools may be obviated by a careful choice and preparation of the ground, and by watering or oiling. Nose-breathing should be inculcated and also the routine practice of rinsing out the mouth and gargling before drinking.

Systematic measures of conservancy will tend to mitigate *pro tanto* the plague of flies and a study of the natural history of these pests will doubtless provide indications for a more direct campaign of suppression. We have seen (Chap. VII.) that biological methods of sewage-disposal have a special justification in this connexion.

In concluding this section on prophylaxis, a few remarks may be offered on some points connected with the domestic economy of the soldier's life : the food supplies and cooking arrangements, clothing and personal hygiene in general. Much has been done, and more is in contemplation, for the improvement of the authorized rations, in regard to quality, variety, sources of supply and preparation. It is proposed to establish central dining halls for companies when barracks are constructed on the new and revised plan, and these halls will be provided with cupboards for such supplementary food supplies as the soldier affects and which have now to be kept in his kit-box. Dairy farms have been instituted in some stations, and in many others there are regimental dairies and aërated water factories where all the arrangements are made on, and maintained at, a high sanitary standard. A great deal of care has been bestowed on the kitchens, which, however, by their structure, position and arrangements are altogether ill-adapted to respond to these efforts ; they have, in the past, been relegated to the ignorant low-caste native servants, who could not be expected to live up to responsibilities they do not recognize, and whose primitive habits are reflected in their surroundings. The kitchen in India has everywhere been cut off from the house and become the stronghold of the native cook and his satellites with disastrous results : the majority of housekeepers, who may be scrupulous in the care they bestow on bed-room and sitting-room, are strangers to their kitchen, where, generally, their presence would be resented. The folly of this ostrich-like policy is now becoming recognized and nowhere more clearly than in the army, and a radical alteration in theory and practice cannot be carried out too soon. Already a great advance has been made in many regiments in the way of training the men themselves to prepare their own food in regard to all the manipulations required, and the system must be extended till it prevails exclusively. But with this, every facility must be given for the hygienic conduct of the difficult and delicate work ; labour and money would be lost by endeavouring to palliate the present arrangements in most cases, and reform should not stop short of new structures with all the necessary equipment on modern lines, including proper ranges, and separate scullery and sink with immediate covered drainage to the place of disposal. The kitchen will, of course, be removed from contiguity with the latrine, and it would be well to make it an annexe of the dining hall or, better still, to locate it above the latter, a lift being provided to obviate human traffic between the two. There is no obvious reason for the employment of natives in any capacity in the kitchens, and it is least desirable in the hot weather when Enteric Fever is most likely to occur ; the fact that Europeans pass long hours on duty as engine drivers in the hottest season provides a good precedent for this most necessary service. So much depends on conscientious care in details, and domestic economy is so peculiarly a woman's province, that it becomes a practical question whether it would not be well to confide the general management and supervision of the kitchen operations to educated women (as in the case of the Nursing Service), or to qualified stewards selected from the ranks : this, of course, should not involve any delegation or diminution of the Medical Officer's responsibility or authority. For it is just in these details of domestic hygiene that we may reap the fruit of bacteriological knowledge, not in the hunting down of particular germ pests, but in the refined sense of order and cleanliness it evolves and educates. In regard to all measures of conservancy (including that of the water-supply) and of food supplies and kitchen service a cardinal element in success is to eliminate the native as far as possible ; camp followers have always been the bane of an army, and the ideal soldier is he who can dispense with these dangerous allies, who, indeed, are enemies within the camp. It is, doubtless, one secret of Japanese efficiency in the field, that the men depend upon their own resources, and nearer home, the soldier may find a worthy example in the proverbial "handiness" of the British seaman.

Under the improved organization and supervision suggested, much may be done in the way of improving the quality and variety of the rations and of adjusting them to physiological requirements. The following statement is extracted from the weekly letter of the army correspondent of a leading Indian newspaper, in which, however, in the writer's opinion, the choice of meat dishes is needlessly embarrassing to both mind and stomach and would not represent the ideal for India.*

"The restaurant system of messing is being tried on an extensive scale at the Rifle Depôt, Winchester, and the variety of *menu* shows what can be done with a soldier's rations in the hands of an experienced cook, with the ordinary accommodation met with in barracks. The old method of drawing company rations and taking them to the cookhouse is dispensed with, for the company's kitchen is now converted into a restaurant, and a large blackboard fixed near the entrance contains a chalked statement of the day's *menu* prepared for the soldier. The following is one of the dinners, a fair example of the new style :—

Soups—Thick, clear.
Joints—Hot: roast or boiled beef, boiled mutton; cold: roast or boiled beef.
Entrees—Mutton chops and tomatoes, meat pies, curry, stew, and rice.
Vegetables—Potatoes, cabbages, turnips, parsnips, beans and peas.
Sweets—Currant roll, date pudding, boiled rice and currants.
Cheese and pickles.

The bill of fare is drawn up by the Master Cook of the depôt, and submitted to the Quartermaster, who approves, after satisfying himself that the men's messing account is on the safe financial side. The meat ration is arranged with the contractor at the rate of $\frac{3}{4}$ lb. per man in mess, and the other edibles required to complete the day's messing are procured locally each day, and the cost borne by a charge of $3\frac{1}{2}$*d. per diem* set aside from each man's pay. The men go to their kitchen, select their dishes and repair to the barrack room with them. Extras are also forthcoming for breakfast in the shape of liver and bacon, fish, jam, eggs, and butter or dripping for tea ; and there is often a basin of soup for supper, and sometimes bread and cheese. The residue of the day's dinner-fare is distributed after the tea bugle has sounded, and the soldier has no reason to spend his pay in the coffee bars or institutions usually made attractive as supper bars, since his rapacious appetite can be satisfied at all times from his own company's kitchen. Winchester is not alone in the experiment of combined messing, which is being carried out successfully at Aldershot, Shorncliffe, and other stations. In some cases separate rooms are set apart for dining purposes, and in one instance a pint bottle of ale is procurable by the men in their dining-room for twopence under arrangements made with

* The institution of scientific experiments to determine the dietetic requirements of the soldier in India is a matter of most urgent importance; see Chittenden's remarkable work in America, which necessitates a revision of all our ideas and standards.

the local brewery. Crime has diminished at stations where the soldier's food has been improved, and such is the success of restaurant messing that the authorities are likely to give the increased accommodation so badly wanted in many cases, which at present hampers its introduction."

The scullery and pantry accommodation and equipment is of the first importance; they must be separate alike from each other and from the kitchen. If water be laid on to the former with simple means of heating it, and if racks for utensils and a sink and proper drains be provided, a whole series of mischances will be obviated. In the pantry, which like the scullery should be tiled, all food must be stored in wire safes, or, in the case of milk, in locked cans provided with taps.

The special dangers attending the consumption of raw foods needs no emphasis, and an adequate supply of vegetables and fruit should be provided under regimental auspices, so that the men may have no excuse for resorting to the bazaar or to casual hawkers, who must be strictly excluded from cantonments. Regimental gardens may well be instituted for the supply of vegetables; many of the difficulties would be overcome with a water-carriage system of removal with disposal by "biological" methods. All these internal resources, with greater variety and due delicacy in the cooking and serving of the food, will tend to remove the chief inducement to resort to the bazaar eating houses, and these could reasonably be placed out of bounds or be registered for inspection and supervision as in the case of lodging-houses. There should certainly be co-operation to this end with the authorities responsible for the various soldiers' homes and other similar agencies.

In regard to clothing the modern soldier is at a great advantage as compared with his predecessor, but here too much is left to his own scanty resources (see Chapter III.), especially in the way of underclothing and in view of the necessity for its more frequent change in this climate. Experiments are required to determine the most suitable colour and texture of the fabric worn beneath the white drill in the hot weather, and indeed at all times and in all places where the sun's rays are exceptionally powerful. In this respect we need to apply the indications derived from nature's provision of pigment in the case of natives.

The methods hitherto in vogue for cleansing clothing and bedding and all kitchen and scullery cloths present another example of our dependence on the natives and their primitive resources, and it is fully recognized that a properly-equipped laundry is an essential adjunct to every well-ordered cantonment to supplement the arrangements for disinfection. Apart from the obvious necessity of this provision on its own merits it will foster a higher standard of personal cleanliness in all other respects, for which more systematic arrangements must also be made in the way of additional under-clothing and of hot-water baths, the value of which will be enhanced by the routine scrubbing of the integument with soap; the toilet of the mouth and teeth must be inculcated to prevent oral sepsis. There is good reason for suspecting the ordinary plunge-bath in common use of a rôle in the communication of specific bowel infections.

Judicious precautions must be observed to prevent the exposure of the younger men especially, to the effects of excessive bodily exertion under a tropical sun, such as is frequently involved in marches, musketry practice and in the riding schools. The intelligence of the men must be enlisted against the dangers of dietetic follies and excesses, in the matter both of eating and drinking, than which no more potent predisposing causes of disease and of mental and physical inefficiency prevail, especially in combination with the physiological depression and embarrassment induced by "fatigue." Properly adjusted and regular exercises and diet, which connote what is recognized in empirical experience as "training"—not over-training—are at once the best preventives of disease and the best preparation for the duties demanded of the soldier.

All these matters may be regarded as trifling details, but apart from their individual and intrinsic importance they subserve the whole end in view, and they will yield results beyond their application to the prevention of Enteric Fever. They have their place in a scientific and comprehensive scheme of prophylaxis, and to neglect them is to jeopardise the results of more imposing measures.

One fundamental consideration must be faced, and that is the necessity for a wisely liberal financial policy. The course of endeavour in the past has been strewn with stumbling blocks due to a neglect to apprehend and act upon this principle. In the last A. M. D. Report (1904), we find it stated that "impermeable floors will be provided for latrines and urinals *as funds allow*," and this is but one of many similar evidences of short-sighted extravagance masquerading in the guise of economy which the records furnish. Meanwhile partial expedients and experiments, which in the aggregate cost large sums, are sanctioned ; "they have their little day and cease to be." There is a middle-way between a wholesale whoring after new inventions and a policy of *fainéance* or compromise ; that way is now sufficiently clear before us, and what may stand as excuse in the past will justify the greater condemnation in the future if we evade it.

In consonance with the view of extra-cantonment sources of infection, so largely held by medical officers, it is not strange that there is a strong consensus that in the present state of the sanitation or insanitation of the affiliated bazaars, they should be put "out of bounds" for the troops. The Cantonment Code which came into force only in October 1899, is a belated attempt to deal with this difficult problem, and Major (now Lieutenant-Colonel) Firth, R.A.M.C., late Special Sanitary Officer of the Rawal Pindi District and now Professor of Hygiene at Netley, offered some strong but judicious criticism of the Code in his report for 1899-1900, which the authorities would do well to consider. The Cantonment Magistrates are the Executive Sanitary Officers, and these are supposed to get their technical advice from the " Sanitary Officer," who is a member of the Cantonment Committee. In the majority of cantonments no specially qualified Health Officer had then been appointed, and the sanitary adviser was practically the senior executive medical officer in the station. Work of this kind involving special knowledge and training in a science that is making great strides yearly, if not almost monthly, can only be expected of an expert. Again, of the Cantonment Committees, Major Firth says : " I fear but few Cantonment Committees will rise to a sufficient appreciation of their powers and responsibilities." He points to the apathy engendered during the hot and rainy months (the period of danger), when everyone is inclined to let abuses stand over for attention till the next cold season. There is a most undesirable lack of continuity in the administration, and "it comes to this that in nine cases out of ten, the activity, zeal and initiative of the Magistrate are the true measure of the efficiency of the local sanitary authority." The provisions under the Code as to bye-laws are too lax and permissive, and this particularly with regard to the control of trades, etc., from which most of the danger to the troops is considered to arise ; and "the multiplication of sanitary officers will, and can do nothing if the law allows any loophole for escaping conformity with sanitary requirements." In the important matter of conserving a pure water-supply, we find it enacted that "no person shall, without permission, place any latrine, cesspool, urinal or drain, or use for the deposit of offensive matter or rubbish, any place within fifty feet of any source of public water-supply." Any "person" may, it would seem, put his latrine at a distance of fifty feet, or nearer "with permission." Again, the provisions laid down (sections 73 and 76) as regards latrines, are not calculated to arouse the enthusiasm of the most luke-warm sanitary reformer. Major Firth concludes by saying that "we can only hope for very gradual improvements, as a result of a judicious combination of cajoling and menace on the part of officials," "but success in this direction is purely that of the individual and not of the administration." It must be affirmed that neither the specific provisions of the Code, nor the authority to which their execution is entrusted (with the large amount of judicial and office work this individual has to perform) provide a basis for sanguine anticipation; menace and cajolery are feeble agents to depend on. By the time the ground has been covered at infinite trouble those who were first cajoled into some reform have relapsed, and so the work goes on *da capo*. For ignorant people it must be made as easy to do well as to do ill, and nothing will avail but radical reforms in all the practical measures by which a community can live cleanly and righteously in a sanitary sense.

These considerations have an obvious application to cantonments themselves, including those parts of the site in contiguity which are occupied by the dwellings of officers and civilians, the conservancy arrangements for which are too often neglected for lack of a systematic and comprehensive sanitary organization with adequate resources and control. While endeavouring to secure the first essentials of a pure-water supply and the complete removal and disposal of excreta and refuse in these affiliated areas, the accurate registration of all deaths and their causes is a measure, the importance of which can scarcely be exaggerated. In a word, organization and authority must be extended and co-ordinated in control of the dangerous zone that intervenes between the general native population and the troops in cantonments.

A considerable, if uncertain, proportion of Enteric Fever infections are contracted on journeys by road and rail; the neglect of the commonest sanitary arrangements in railway refreshment rooms and dâk bungalows is a crying scandal. If we cannot reform those sloughs of despond known as hotels, it is certainly incumbent on the authorities to put the former, which are State institutions, under strict sanitary discipline, and this can only be effected by general ordinance giving the necessary powers and providing penalties for default.

This leads us to the question of the sanitation of troops on the march and in camp. The annals of route-marching in India, involving frequently the use of the same camping site by successive regiments at short intervals, are rich in records of epidemics. In these camps we have every source of pollution of the soil, by badly arranged and badly conserved latrines, by want of care in trenching, by accumulation of waste liquids and decaying organic matter. If we look at the medical history of the campaign in South Africa, all this and its results are brought home to us in the terrible figures of mortality and sickness from Enteric Fever and other bowel diseases. If we wish for peace we must prepare for war, and to be ready for war we must prepare in time of peace ; moreover, with regard to Enteric Fever we may not maintain two attitudes, one only being possible, *viz.*, that of war. Camping sites along the main routes and those subject to repeated occupation must be brought under ordered control, provided with the necessary arrangements and strictly conserved at all times, and not merely subjected to hasty intermittent efforts which at best assume the nature of compromises at the time of occupation, and for which the individual corps unit is responsible. But in all cases, we must expect more from our medical officers than valour in the front line and surgical skill in the field and base hospitals ; each regimental unit must have its sanitary preventive patrol or vedette, which should be mounted, and to this end some of the more intelligent men must be trained in peace. Part of this sanitary guard should precede the regiment on the march, and part should follow after taking all measures to conserve and disinfect the camp. The Medical Service should have an independent transport entirely at its disposal. The whole problem is beset by difficulties when forced marches in a campaign have to be undertaken, but that is no reason why they should be shirked, and this matter is one of the most pressing in the whole question of military reform. The Japanese in the recent war have furnished a striking object-lesson of the results of preparation and organization in this direction, and it must be insisted that this training and organization can be instituted successfully only during peace, and that combatant officers and men must co-operate to the end in view.

We have now to summarize as briefly as possible the general principles that should guide us, and the practical measures thereby indicated, in combating an actual outbreak of Enteric Fever.

Starting with a due appreciation of the parasitic faculty of the bacillus, the fundamental principle of action must be the definite identification of its presence with the aim to its destruction, and the prevention of its propagation and dissemination ; this identification may (and must often) fall short of positive demonstration of the bacillus itself, and we must then fall back on the more indirect evidence, which, in the last resort, is derived from the clinical symptoms. The failure of our efforts in the past has, however, been due largely to our dependance on this last resource ; the protean features of the malady and the established fact of the frequent infection of the apparently healthy, has rendered exact bacteriological methods indispensable, and the success and economy of our efforts will be proportionate to the skill and energy displayed in their application. Outbreaks are always and everywhere the result of the effective access of the bacilli derived from previous cases from which they obtain passage directly in the excreta (fæces, urine, sputa) or indirectly by articles contaminated thereby (clothing, vessels, food, &c.) ; the danger is *ceteris paribus* in proportion to the extent of the susceptible population exposed, of its close aggregation and use of common resorts and common services. While in the active combat with an outbreak every possible means of transmission is to be taken into account, it is often impossible to mark down each and every *fomes* in detail ; and when infection is present in a community, constant and cumbrous precautions against all indirect modes of transmission are sooner or later as futile as they are exacting. The cardinal indication is, therefore, to attack the evil at its origin—the infected host—while maintaining a high standard of public and personal hygiene. At the same time investigation must be directed to trace each case backward to its source and then to determine the area of influence of the infection. We may thus hope to secure the identification of all who are infected and to determine the duration of their infectiveness.

These ends can only be achieved successfully and economically with the skilled resources of bacteriology which must be made available by the institution of laboratories for the work of investigation and diagnosis at the hands of traine experts, whose primary function must be the examination of all suspected materials. Their results along with the information supplied by the medical officers on the spot will secure the "intelligence" by which active measures must be directed, a Register being maintained at each centre for the record of all the essential facts elucidated: name of patient, date of illness, age, service, corps unit, barrack, bed, mess, latrine, etc., with a statement of any (and what) connexion with previous cases or centres of the disease, and the nature of the material examined and the results, whether blood reaction, positive find of bacilli, etc. Outline maps of the cantonment, showing dormitories, latrines, wells, etc., must be spotted (with numbers and dates) to exhibit the local and time relation of the cases. The ensuing investigation should be pursued upon the spot and embrace enquiries as to the source and means of the infection, and be directed primarily to determine the questions of importation, of water or food or more direct contact infection. It should then extend to the men living in the same dormitory or barrack, and to those resorting to the same mess or latrine as the patient, recent visitors thereto from other units not being overlooked; and it should take strict account of all forms of febrile illness or bowel disturbance however slight.

The procedure laid down by the German Imperial Board of Health for the diagnosis of the disease and for the examination of suspected materials may be given in brief outline as follows: the details are extracted from the official Memorandum on "*Measures for combating Typhoid Fever*" issued in 1903.

The substances sent to the laboratory for examination should be:—

(1) Fæcal matters: 50 to 100 c.c. if liquid; of the size of a nut if solid.

(2) Urine, 500 c.c.

(3) Blood, taken by scarification of rose spots.

(4) Expectoration from the lung.

(5) Pus, or inflammatory exudations.

(6). Blood, taken (*a*) by puncture of an arm vein (2 or 3 c.c.) (*b*) from the lobule of the ear.

(7). Soiled linen.

(8). From a dead body; intestinal contents taken from above the ileo-cæcal valve, portion of spleen and lung; some bile, contents of abscess; pulmonary secretion.

(9). Well-water, after the well has been stirred up, from 3 to 5 litres.

The operations to be performed are: cultivations, agglutination test, Pfeiffer's test.

(1) *Cultivations.*

(*a*). Substances 1, 4, 5, 7 and 8. At least two series of large Petri dishes are plated with Drigalski-Conradi medium, and incubated at 37° C. for eighteen to twenty-four hours.

(*b*). Urine—Centrifugalise and cultivate from the deposit as (*a*).

(*c*). Blood.—Inoculate into alkaline peptone bouillon, using 10 c.c. tubes for No. 3, and 150 c.c. flasks for No. 6. Incubate at 37° C for twenty hours, and sow into Petri dishes as (*a*).

(*d*). Water.—Place in a 2-litre flask. Add (for 2 litres of water) 20 c.c. sterilised solution (7.75 p.c.) of hyposulphite of soda (German Pharmacopœia). Mix. Add 20 c.c. sterilized solution (10 p. c.) of nitrate of lead. A deposit is obtained, either by centrifuge or by sedimentation for twenty-four hours: pour off supernatant water, add to the deposit 14 c.c. sterilized solution (100 p. c.) of hyposulphite of soda, shake, and decant into a small sterilised tube; allow the insoluble matters to settle. With the liquid portion, prepare Petri plates (2 to 5 cc. in each) as with fæcal matters. Colonies are examined with the naked eye by daylight, as to their size, colour and transparency; those suspected of being B. typhosus (which are small, transparent blue-violet in colour) are examined microscopically afterwards under a low power, as to their behaviour in the presence of a strongly agglutinating serum. Pure cultures are then made on sloped agar.

The final determination is made (A) by examining the shape and motility of the organism; (B) cultivation in glucose agar; (C) in litmus whey; (D) on potato; (E) on gelatine; (F) agglutination test microscopically; and (G) by Pfeiffer's test.

(2) *Agglutination Tests.*

For the determination of a suspected colony or pure culture, these are carried out (*a*) in hanging-drop with direct addition of serum; and (*b*) in dilutions of $\frac{1}{50}$, $\frac{1}{100}$, $\frac{1}{500}$, $\frac{1}{1000}$ and $\frac{1}{2000}$, each experiment being repeated with the same culture and the same dilutions, and with a known typhoid culture of the same age and the control serum. For the examination of the blood, a microscopic test is made with $\frac{1}{50}$ and $\frac{1}{100}$ of the suspected serum and a forty-eight-hour typhoid culture; microscopic examination is also made in conical tubes, left for three hours at 37° C. If $\frac{1}{50}$ gives positive reaction and $\frac{1}{100}$ negative, the case is doubtful, and the test should be repeated a few days later.

(3) Pfeiffer's Test.

The serum employed must have a strong agglutinating power. Four guinea-pigs are taken: A receives a fivefold immunising dose; B a tenfold dose; C is a control, receiving a fiftyfold dose of normal serum; these animals are injected with doses of serum containing a loop of the culture to be examined (eighteen hours on agar, and then diluted with one c.c. bouillon). D receives an injection of a quarter of a loop of the culture simply, this serves as a test for its virulence. The peritoneal exudation is examined in hanging drop under a high power from twenty minutes to one or two hours after the injection. In A and B the bacilli should be dissolved or transformed into granules; in C and D a large number of bacteria should be quite motile and retain their characteristic form.

In the application of the campaign against typhoid to military practice, the examination of water supplies is not to be omitted. This mode of infection may be obviated in some degree if a bacterioscopic water examination is made at regular intervals, not to discover the enteric bacillus, which practically is never found there, but to ascertain the presence and amount of colon bacilli, which are the proof of fæcal pollution and an indication of possible contamination by Eberth's bacillus. In Koch's opinion, no filter can safeguard against this danger of infection by water; sterilisation is the only method to employ.

The essential end to which the procedure is directed is the rapid identification of the infective agent by one or other of the processes according to the circumstances of the case, and this has been facilitated by the special culture medium introduced by von Drigalski and Conradi mentioned above, which consists of lactose litmus agar containing crystal-violet. This differentiates the colonies of *B. coli* which are coloured red, from those of *B. typhosus* which remain translucent and bluish, and can thus be picked out and identified by the agglutination and other tests, the diagnosis being completed in from 24 to 48 hours. It is probable that finality has not been attained in this matter of technique which demands considerable skill and experience in its employment, but that it marks a great advance to a practicable solution of the difficulties, there can be no doubt. More recently, Lentz and Tietz and Endo have introduced to notice selective media of a similar kind, in essential principles, which would appear to have a sphere of usefulness in examinations of the fæces, possibly as supplements or complements to the Drigalski-Conradi process, but experience alone can decide as to their relative advantages in different cases. In this connexion we may not omit mention of the procedure elaborated by Hoffman and Ficker for the detection of *B. typhosus* in water, in which similar materials are employed but with a special adaptation to the exceptionally difficult problem, and which has been attended with striking success (see v. Jaksch, *Contralblatt fur Bakteriologie, Orig.*, XXXVI., No. 4, 1904).

A few words may be added on the present position, legitimate indications and the requirements in practice, of the Gruber-Widal serum test. It is not denied by any competent observer that it is certainly a valuable aid to diagnosis, that it is, indeed, indispensable ; and we may hope that with the advance of our knowledge of the biochemical forces in action we may find in its very limitations surer evidence of its true worth. Failure has often been due to the use of haphazard methods and to a lack of appreciation of the obscure differences that mark different strains of the same micro-organism obtained from different sources and cultivated under varying conditions in the laboratory. And to this must be added the variations in the reaction of the tissues of the organism which provide the conditions for agglutination, and in the personal equation of different observers. It may be concluded that while in the laboratory we can control, more or less, the factors in operation, the clinical problem may be complicated by the individuality of the case ; that no single test or symptom can be relied on exclusively, but that the Gruber-Widal reaction will maintain its value when its results are read in the light of all the clinical syndromata, and beyond this, it will, in the majority of cases, render a relative service to the patient, the clinician and the epidemiologist by furnishing evidence of specific infection, past or present. In using it, any idea of obtaining indications from arbitrarily fixed dilutions must be abandoned ; in each case the observer must exhaust the limits of the reaction of the serum on the different micro-organisms of authentic identity and origin which may have a possible etiological connexion with the case, and so refer not to "positive" or "negative" results, but state the facts. Any simplification of the test that does not involve loss of accuracy would prove more profitable than an ever-increasing complexity of technique, with its tax on the judgment of the observer. From the consensus of a large and increasing number of reliable authorities who have used it in comparative tests with the Gruber-Widal procedure, it would appear that Ficker's so-called "diagnosticum" fulfils this demand. Along with the abundant testimony to its delicacy and reliability, it is recommended for its simplicity and its availability to the clinician in the absence of laboratory resources, and as altogether specially adapted to the conditions of military hospital practice.

From this sketch of the scope and functions of the intelligence department we may proceed to summarize the measures to which the striking and defensive forces are to be devoted ; the plan of campaign is that elaborated by the German Imperial Board of Health and is the outcome of the results of the scientific Commission organized by Koch for the suppression of endemic Enteric Fever in the villages of the Hochwald in 1901, which were confirmed by the success of the operations subsequently carried out in Saarbruck, Treves, Metz and Strasburg by von Drigalski and Frosch. (Talayrach, "*Archiv. Med. et Pharm. Militaires*", No. 11, November 1903.) The general principles of action may be referred to under the following heads : (1) Notification ; (2) Investigation and Diagnosis ; (3) Isolation and segregation (evacuation) ; (4) Disinfection ; (5) Instruction.

Of the first two, the requirements and scope have already been indicated ; the importance of the earliest possible recognition of all cases, whether typical or suspect, has been amply demonstrated in the facts adduced as regards the average duration of treatment in our Indian hospitals, and we must no longer be content to refer the responsibility to the disinclination of the men to "report sick." Reference has been made to the necessity of enlisting the intelligent co-operation of the men by all the means which come under the head of Instruction ; and for the rest we must depend on systematic supervision and investigation, to which the Register and Spot maps are indispensable aids and which, at all times, may be guided by the indications derived from the observations in hospital (daily sick state and admissions). Frequent and regular examinations of the men will come into this category. When diagnosis is established, notification should extend to neighbouring stations and especially to those upon a line of march or in direct communication. There should also be interchange of notification between the civil and military authorities of the same cantonment; advice to the local authorities in advance of projected movements from an infected place, which will apply to departures to the hills, and to convalescents proceeding on leave; and the notification of cases that exhibit infection on return from leave, or from duty in other stations, to the Senior Medical Officer of such stations.

As regards (2) *Diagnosis*, nothing need be added to the statement of the procedure to be followed, beyond urging the adoption of a more vigorous and systematic policy in providing and using the necessary resources. Out of 1,397 admissions for the disease in India during 1904 there is a record of only 749 individual cases submitted to the serum reaction, of which 526 were declared "positive," 198 "negative" and 25 "doubtful." In only 50 of the 86 stations in which Enteric Fever was recorded was the blood test employed as a routine procedure. In all other directions concerning the identification of the specific bacillus or its allies the record for the year is blank (save as regards its detection in the urine in several cases), and only occasional attempts have been made to isolate the micro-organism from the tissues *post-mortem*, and so to confirm the positive pronouncement of Fischer (Kiel) as to its specific identity, which was made in 1890, from specimens submitted to his judgment. The work of Captain Blake-Knox on Typhoid bacilluria was conducted at Netley and furnishes a good example of the observations demanded. It need scarcely be pointed out that a systematic utilization of our scientific resources will contribute materially to the elucidation of the pathology and etiology of other diseases, and especially of the fevers and bowel diseases which are a reproach alike to our nosology and to our preventive efforts. And it is clear that with the concentration of the forces under the new reorganization scheme, there will not only be a more imperative demand for laboratory provision, but also less need of dissipation of the resources in that respect, and this, in any case, is a comparatively trifling matter in view of the issues at stake,—the essential element of success being the men to be entrusted with the work. With diagnosis, investigation of the sources and area of infection should go hand in hand, and this of course, as already stated, will take account of the more dangerous, because more occult, forms of infection in cases before and after the clinical symptoms are manifest, and also of the direct and indirect means of dissemination ; and this again, will naturally lead to the necessary measures, *e.g.* the exclusion from access to the implicated focus, well, cook-house, latrine, bath, riding school, or barrack, etc.

(3) *Isolation and segregation.* Allusion has been made to the necessity of a precautionary measure of quarantine to be applied to drafts on first arrival and of bodies of men arriving from a centre where the disease exists or has recently existed. This applies to the annual movements in relief, of those to the hills and of those of time-expired men. Inter-station transfers should be avoided as far as possible at the seasons of notable prevalence, and it is obvious that the greatest care must be exercised in regard to the aggregation of corps units from different places in camps, and to the movements and communications involved thereby. These inalienable conditions of army life and function render a perfect integral organization for sanitary purposes an essential part of the equipment and establishment of each corps unit, apart from the general organization which controls the whole : each unit must be equipped and responsible for its sanitary service, otherwise aggregation must always introduce special dangers.

On the occurrence of an outbreak the sufferers must of course be removed to isolation wards set apart and adapted for their treatment, while suspected cases and contacts must be segregated also for a period of observation of three weeks, in special quarters provided for the purpose. In regard to cases established by diagnosis which end in recovery, the ideal to be aimed at is to prevent a return to association until the period of infectiveness has ceased ; this can only be adequately secured by a resort to routine bacteriological examinations of the excreta, two consecutive negative results at weekly intervals being decisive. The alternative is prolonged isolation or banishment to a station set apart for convalescents, which is obviously costly in the loss of effective service involved and affords no guarantee of safety in the end. To sum up ; when a case appears in a barrack, it is advisable to cut off from use the attached mess and latrine, and to institute the mess in spare quarters. The patient is to be removed to the isolation ward, while the other men previously in association, and now under observation take their meals and exercise and use a latrine apart from the rest for a period of at least three weeks ; suspicious cases of fever, diarrhœa, etc., should further be isolated from the contacts in question and the resources of bacteriology applied to the blood and excreta for the identification of the specific infection. Such measures are doubtless exacting, but that they are reasonable and practicable has been already proved by their success in cutting short an epidemic of Paratyphoid in the garrison at Saarbruck in 1902; and it must be noted that the whole aim is to discover the beginnings of evil, and that the success achieved will be in direct proportion to the provision made beforehand and to the promptness and energy displayed at the outset. The aim in view is to cut the channels of communication between the sick and the more indirect sources of infection and the healthy;—by removal and isolation of the former and of others possibly infected; by the destruction of the virus; by the prevention of subsequent intercommunication during the period of infection (as by nurses, attendants, visitors, flies and dust); and by the abrogation of common services (water and food) and resorts (latrines and messes) which may have been previously infected.

4. *Evacuation and movement* is a measure which is obviously included by implication in the previous category, and merely deserves separate mention for the proof it has afforded by its success of the danger of the indirect sources of infection, when an outbreak is widespread and has defied half measures. It is, in fact, a wholesale form of segregation from multiple sources of infection which are present in barracks, latrines, messes, the soil of the site, the water and food supplies; but while it serves to establish the etiological connexion with these sources, it is, in itself, a partial and blind expedient unless employed as preliminary and ancillary to a more definite and comprehensive plan of campaign; it is at present our chief resource against plague in the native civil population, as for long it availed us against cholera among the troops, in regard to which we have advanced to a stronger and more offensive position.

5. *Disinfection.* The foregoing measures all lead up to the prompt and complete destruction of the infective agent, on which, indeed, their justification and success depends, the object being to arrest and destroy the virus at its prime source, and, failing this, in all secondary foci in which it has found more or less temporary conditions for viability. Premising that when a case is admitted to hospital with ill-defined symptoms which, in the absence of a positive diagnosis, arouse suspicion of the possibility of Enteric Fever, he should be placed in an observation ward set apart for doubtful cases and all precautions

taken as for the established disease, we have to take account of the following sources and means of infection.

1. The patient and his excreta : Fæces, Urine, Sputa, Vomit, Person.
2. The more immediate environment of the patient, including all articles and places with which he is brought into direct contact before admission and during the period of infection : clothing, bed and bedding ; vessels and utensils of all kinds, including those in use for food, drink and medicine, as well as bed-pans, urinals, etc., and the food itself ; all materials used in the nursing service, towels, soap, swabs, etc., the washing and bathing waste-water and all refuse, sullage, etc.; the walls, floor and furniture of the ward.

Into this category come also the barrack-room, dormitory or tent occupied previous to admission ; the latrine and urinal and mess-room resorted to, as well as the immediate site and open ground surrounding these ; the ambulance or public carriage, if any, occupied by the patient.

3. Other individuals in association with the patient : contacts, doctors, nurses and visitors to the wards.
4. In fatal cases, the corpse and *post-mortem* tissues and fluids.
5. Convalescents.

1. Patients should never be allowed to resort to latrines or closets in common use. All excreta from bowels, bladder or stomach should be caught and retained in easily cleansed vessels with an impermeable and indestructible surface, and which are charged beforehand with a quantity of fluid disinfectant equal to the average of the excreta. The mixture is to be removed from the ward at once and after thorough stirring, it may be allowed to remain in the vessel for an hour before disposal by burning or boiling in a suitable apparatus. Urinals and bed-pans must be cleaned with disinfectant immediately after use and stored in a covered box till next required. Spittoons must always contain disinfectant and be emptied and disinfected frequently and regularly ; their contents should be disposed of as in the case of the other excreta. Swabs of cotton gauze which are used for wiping the patient's mouth, nose or nates, should be deposited in a vessel containing disinfectant and removed at once for burning. The personal toilet of the patient will of course receive scrupulous attention, his hands and nails and nates being regularly cleansed with disinfectant.

All washable clothing, such as body or bed linen should be removed from the ward in a bag which has been wrung out in disinfectant, and should be deposited for one or two hours in a receptacle containing disinfectant in which it may be subsequently boiled, and then finally rinsed in plain fresh water : blankets and woollen articles should not be boiled. Articles of clothing that cannot be washed, and mattresses, carpets, etc., should be disinfected by steam in suitable apparatus under competent supervision. Articles of leather, wood and the metallic parts of furniture, and similar objects soiled by the patient's excreta, should be carefully and repeatedly rubbed with rags moistened in disinfectant, the rags being subsequently burnt.

All feeding utensils should, after use, be thoroughly cleansed with hot solution of soda, or with disinfectant, and subsequently cleansed in the ordinary way. Dusters and other service cloths in use should be treated as infected. No food should be allowed in the ward at other than meal times ; it should never be left exposed or uncovered, and all fragments or portions left over should be destroyed.

Washing and bath-water after use and all sullage must be treated as infected, and rendered innocuous by the addition of sufficient chloride of lime, the mixture being well stirred and retained for one hour before disposal. The walls and floor of the ward and its furniture should be systematically scrubbed with hot disinfectant, particular attention being paid to crevices and corners and to the immediate neighbourhood of the patient's bed ; the rags used being burnt and the brushes disinfected.

Every endeavour must be made to exclude flies from the wards and from the various offices of the hospital, and all intercommunication with other wards must be scrupulously interdicted, save only in the case of the medical officers, who should wear a linen outer-garment in the Enteric ward and disinfect their hands before leaving.

2. It is unnecessary to enter into similar details as regards the disinfection of the patient's environment before admission to hospital : the same principles apply and demand similar measures. When new barracks and dormitories are to be constructed it is to be hoped that in addition to improved arrangements as regards dining halls and kitchens and sanitary equipment in general, special attention will be paid to the materials and structure of walls and floors, to minimise the lodgment of dust and dirt and to facilitate disinfection ; absorbent plaster walls and rough plank floors can never be kept truly clean. The introduction of a water-carriage system of sewage removal, with W. C. latrines, would facilitate greatly the task of disinfecting the latter structures, which, under the present arrangements, must tax the best efforts and resources to a hopeless degree. On the occurrence of a case and the removal of the patient to hospital, all his ordinary regimental clothing, barrack bedding, etc., which must be entirely separate from and surplus to the hospital

equipment in these respects, require disinfection in the manner described, a measure which must be extended, according to circumstances, to the dormitory and its furniture and to the clothing and bedding of immediate contacts. The floor and soil of the site contaminated by the excreta of the sick, as well as pavements, gutters, drains and refuse heaps may be disinfected by the application of chloride of lime or slaked lime.

3. Nurses and orderlies entrusted with the care of Enteric patients should wear easily washable outer-garments, or aprons covering the entire front of the body, which should be reserved for ward duty. After contact with the patient or his body or bed linen, the nurse's hands must be thoroughly cleansed with soap, hot water and nail-brush, and then disinfected with a special solution set apart for the purpose, hot water and disinfectant being "laid on" to a lavatory in the ward, with proper automatic drainage. Caution must be exercised in washing and bathing the patient to avoid splashing. Nurses are to be specially warned against touching food before disinfecting the hands; they should never take meals in the ward, where also smoking (in the case of orderlies) should be strictly prohibited. The precautions as to disinfection apply equally to medical officers, chaplains and visitors. It is reported (A. M. D. Report, 1904) that, in spite of regulations and instruction, nursing orderlies are frequently most careless of the risks of infection, in neglecting to wash their hands before leaving the wards, and in the use of the patient's drinking vessels. These men when they themselves escape, may also be a means of the dissemination of the infection among others with whom they associate when off ward duty; if it is essential that they should continue to be so employed, they should, of course, undergo special training and be provided with special quarters including messing arrangements, and all intercourse with the corps or garrison at large should be interdicted during an outbreak: short spells of duty and plenty of open-air exercise must, however, be provided for. The new nursing service composed of trained women will, it is to be hoped, be organized and extended to obviate the necessity of employing orderlies from among the men, save perhaps, as a small auxiliary corps set apart for the purpose and to meet the requirements of field service.

4. Corpses of Enteric Fever patients are infectious and they should be wrapped in a sheet wrung out in disinfectant and removed to the mortuary as soon as possible. The greatest

care should be exercised as to the disinfection and disposal of all *post-mortem* fluids and material including the water employed during the examination and in the cleansing of the room, the furniture and instruments; open, outside drains or catch-pits are in this connexion, specially dangerous, and the access of flies must be absolutely prevented. The corpse must be enclosed in an air-tight coffin, the bottom of which is covered with a plentiful layer of sawdust or some absorbent material, and it should be conveyed to the cemetery on a carriage which is to be subsequently disinfected.

5. As already stated convalescents must be segregated after discharge from hospital during the period of infection, which can only be safely and accurately determined by bacteriological tests. They will ordinarily be sent to the Hills or to some central depôt where they can associate with others in like case, and be under supervision and control, and the greatest care must be taken to prevent the dissemination of infection *en route*, arrangements being made for the reception, disinfection and disposal of their excreta. The greatest danger at this stage is now known to arise from the elimination of the bacilli in the urine, in which they rarely appear until the end of the second week of the illness, but in which they may, and often do, persist for weeks and even for many months, if untreated. Fortunately, we have in urotropine a remedy which is of proved efficacy in disinfecting the urinary passages and excretion, and Blake-Knox, who has made valuable observations on the subject of Enteric bacilluria generally and of the use of urotropine in particular, has found the best results to follow the administration of the drug in 10 grain doses three times a day given, preferably, from the onset of convalescence, or previously if obvious signs of bacilluria (turbidity) are present. He advises its administration in milk and soda-water (half a pint) or in lemonade made from fresh lemons, "until the urine clears and keeps clear"; it should, however, be noted that this result is generally attained after a short course of the drug and that the bacilluria may return if the course be suspended prematurely. The recourse to bacteriological tests is here again obviously indicated. It need scarcely be added that the disinfection and effective disposal of the alvine excreta are not to be neglected. The personal effects of convalescents must of course be thoroughly disinfected finally before they are allowed to return to the community. The case of convalescents proceeding on furlough requires special consideration and precautionary measures, and

it is essential that they should be excluded from camps and campaign service until they have been proved free from infection. Lastly, troop-trains, tents and ambulances of all kinds must not be overlooked in connexion with the efforts made to destroy the virus in all probable and possible places and objects exposed to the risk of infection.

These, then, are the measures which are indicated by the cardinal fact that the human host is the prime and essential source of infection, and that his every excretion may contain the virus at some time or another during the course of the disease, and that everything with which he is brought into contact may sooner or later be specifically contaminated. This provides the key to what may, at first sight, appear a most complicated and exhausting procedure, but which is indeed simple and feasible when the clue is grasped and followed with ordinary intelligence, though here as in other matters scientific methods in alliance will economize and co-ordinate efforts.

As regards the materials and agents to be depended on for effective disinfection little need be said in this place; the subject is one which has an extensive literature of its own, and there is no lack of competent guidance in all essentials. In the case before us our resources may be summarised as:—

(*a*) Dry heat, including incineration by fire, and also sunlight and ventilation, as to which the special and general applications need no further indication.

(*b*) Moist heat, by steam in special apparatus devised for the purpose, and by boiling. As regards the former all apparatus are not of equal value, the three essential conditions of efficiency being, that the steam shall be saturated, that it shall reach a temperature of at least 212° Fahr., and that the articles submitted to its action shall not be damaged. Every steam disinfector requires skilled and trustworthy handling by a competent subordinate and careful supervision by the medical officer. The expense of this apparatus should certainly not be allowed to stand in the way of its provision in all cantonments, but where it is not available a boiler of some kind must be used, and even for the use of this rules should be prescribed. The vessel employed should be covered, and it should be remembered that the temperature of the fluid will be lowered, whenever a fresh article is plunged therein. It is necessary that everything submitted to disinfection by boiling should be completely immersed and exposed to the boiling temperature for not less than 15 to 30 minutes.

(*c*) Lastly, we rely on chemicals of infinite variety, and of the two or three most generally useful, *viz.*, perchloride of mercury, carbolic acid and chloride of lime, it is most important to secure their purity and adequate strength in solution.

Of these chemical solutions which have a wide and important application in the case of Enteric Fever we may merely refer to a few of the most generally useful, effective and economical. These are the acid perchloride of mercury, 1 in 1,000, hot or cold; the cold non-acidulated solution of the same, of double the strength (1 in 500), for woollen shrinkable fabrics; carbolic acid solution in the proportion of 1 part (weight) of the liquid acid to 20 to 30 parts (weight) of water; the diluted cresole solution recommended by the German Imperial Board of Health, 1 part (weight) of *Liquor cresoli saponatus* (G. P.) mixed with 19 parts (weight) of water, the solution containing 2·5 *per cent* of crude cresole. In addition to these a special application, which need not be indicated in detail, is found for freshly-prepared chloride of lime to be used in a mixture of 1 in 50 of the waste-water or sullage, etc., to be disinfected; and for potash soap (soft, green or black soap) in the proportion of 3 parts (weight) to 100 parts (weight) of boiling water, to be used hot

Lastly, in the general disinfection of wards and barracks, the preliminary use of Formaldehyd may find useful applications.

Anti-Typhoid Inoculation.

It will have been noticed that, so far, no reference has been made to the subject of anti-typhoid inoculation, and this is certainly not because its importance as a prophylactic and sanitary measure is ignored or depreciated. On the contrary, the writer believes firmly that its position in these respects is fully established, though the foremost workers in the field are the first to admit that there are still practical problems to be solved before the sphere and extent of its usefulness can be definitely settled. The scientific committee recently appointed by the Prussian Government, which included Professors Koch, Kolle, Donitz, Kirchner and Gaffky, have stated with all the authority that attaches to their opinion, that the subject is one of national moment. It is recognized that while the incidence of Enteric Fever is, in time of peace, very light, the disease would come to be an all-important factor in regard to the efficiency of the army in the event of a European war, and a still more important factor in a campaign conducted in tropical or subtropical countries. Such considerations have manifestly a far more direct and urgent claim on the attention of the authorities of this country, especially in view of the responsibilities which have constantly to be met in connexion with service abroad and of the eventualities, actual and prospective, which are thereby involved, in peace and war. On the main question of the possibility of successful inoculation, the committee gives its verdict as follows: "On a survey of the scientific observations conducted on animals and men and the practical experience which has already been gained in the case of men, it is impossible, even when proceeding with the greatest caution, to doubt that inoculation can confer a certain measure of protection, and that it is urgently desirable to seek for further information based as far as possible upon absolutely trustworthy data, with regard to the degree and duration of this protection." It is further affirmed that under proper conduct of the process there is no risk of permanent injury to health. These conclusions have not been allowed to die the death of pious opinions of merely academic interest, but have been followed up by an energetic prosecution of practical experiment and of application in the case of the troops despatched to the seat of the war in South-West Africa, no less than 2,000 inoculations having been carried out up to April 1905, in addition to the operations performed among the white and coloured populations on the spot. From a critical survey of the latest results, Kolle has arrived at the conclusion that the inoculation of dead phenolized agar cultures in doses as large as is compatible with safety, affords the best prospect of attaining a protracted period of immunity; the operation should be performed on three successive occasions, at intervals of 8 to 10 days, with increasing doses, from 2 mg. rising to 6 mg., or to 10 mg., if after the second inoculation there is a complete absence of general reaction; these doses are very large, but smaller ones are not, in Kolle's judgment, to be recommended. In view of the prevalence of paratyphoid and of mixed infections in India, the indications are obviously in favour of the use of a polyvalent "vaccine," in place of one composed of a pure *typhosus* culture; the secret of past failure and of future success may lie in the practical appreciation of this suggestion.

Some readers who have followed to this point may look for a separate discussion of the all-important subject of the prevention of Enteric Fever among armies in the field. If this be indeed necessary, after what has been said in regard to principles and practice, the labour of both writer and reader has been in vain ; moreover, the actual details of the measures which are indicated are, at present, the constant subject of discussion in the medical and lay press, the dire experience of the South African war in contrast with the more recent achievements of the Japanese in Manchuria, having provided a fertile text for reformers of more than one faith.

If the principles which have been advocated in the foregoing pages are adequately applied, one source of infection, of a notable but uncertain extent, should be obviated in a very considerable measure if not altogether excluded, *viz.*, its importation from cantonments into the concentration camps and thence along the lines of communication into the field. Too often when mobilization is ordered all the arrangements for sanitary purposes in cantonments and along the line of march are allowed to fall into abeyance, largely due to the fact that, hitherto, the sanitary and purely medical departments of the medical service have not been distinct in their organization, and that again is due to the inadequacy of the cadre at disposal. In plain terms it is impossible to meet the urgent demands for war (which constantly increase with the drain involved in active service) from a cadre that may be expected to barely fulfil the conditions in peace and which is not adequately organized for war. When war breaks out there is a helter-skelter rush to the front and the devil frequently takes the hindmost in their passage along the line previously occupied by their forerunners. It is at this stage that precautions are most necessary, and obviously the necessary organization cannot be improvised at such a time but must be perfected beforehand ; as regards India the circumstances are specially favourable to such precautionary organization, at any rate so far as the strategic lines to the Frontier are concerned. It will begin with the careful selection of the men, with more close and direct application of the regulations to the elimination of all who may harbour infection. It may be impossible to fix a standard of age below which men should not be sent straight away to the field, but those having less than one year's service should be excluded. The training received by officers and men in the principles of sanitation may, at this stage, be expected to bear fruit and to supplement the efforts of the sanitary and medical staffs, and special instructions should be issued to emphasize the particular dangers likely to be incurred and thus to ensure co-operation.

The food and water-supplies demand the most careful attention. Wellington boasted with proper pride, that whatever his merits as a General, he was a good commissariat officer, and to this fact he attributed his successes. An instance of the danger and loss involved in the provision of bad food—in this case mouldy bread—was recently furnished by the plight of the Russian army in Manchuria, which was stricken with enteritis, dysentery and Enteric Fever as a result of its consumption on several occasions. Other radical and sudden changes in the diet, notably the reliance on tinned meats, have been proved to be a fertile source of bowel complaints. The importance of gastro-intestinal disorders as a premonitory sign of an Enteric invasion (and as indication of faulty hygiene in a force) is established beyond all question in the records of campaigns, and, indeed, in the annals of civil communities. Medical officers in India learnt this lesson in the days of Cholera outbreaks, and the same indications should be followed in the attempt to mark down the sources of infection in Enteric Fever. The earliest possible recognition of the milder disorders must be secured and followed by segregation and disinfection, and special supervision of "contacts." The greater care spent on early and apparently trivial bowel disorders and fevers will be well repaid in the prevention of serious outbreaks and in the general maintenance of the health of the whole body. Let it be remembered then that outbreaks of Enteric Fever among troops on field service in the tropics have invariably been preceded by the notable prevalence of "fevers" (generally called "Simple Continued") and of gastro-intestinal disorders, and the experiences of the American concentration camps and of European campaigns all enforce the lesson and its indications.

Allusion has been made previously to the precautions necessary along the routes to the main points of concentration where standing camps are occupied and the army falls into fighting order, to proceed on radiating lines to the front. It is impossible to exaggerate the importance of all sanitary measures at this stage before the army enters the field, and where valuable object lessons may be presented to officers and men for their guidance under the conditions they will encounter subsequently, when each unit will depend on its own sanitary staff to a greater or less extent. The exigencies of the military situation must vary in every campaign, but the salient fact for the soldier and sanitarian alike is the danger of disorderly aggregation of large numbers of corps units from different places. When concentration involves the crowding together of a very large body of men, so that the number occupying an acre exceeds that of the most congested areas of the London slums, and where there is no water-supply nor sewage system which alone make these slums habitable; where every man is a law unto himself and all the worst defects of cantonment conservancy are allowed to prevail, the result can only fail to be disastrous by virtue of happy chance; and the penalty in these cases is too often only deferred. With the extended use of the telephone it is probable that one great necessity for close aggregation will disappear, but the sanitary ideal to be aimed at under all circumstances, must be adequate space and integration of units for sanitary purposes with due regard to the interests of the whole body. And this also involves considerations of great difficulty with regard to the space and accommodation at the disposal of the individual—the size of tents and the number of men allotted to each. In the same connexion it would seem wise to provide on all survey and intelligence maps, indications as to sites for camps and as to the water-supplies available; the first hurried arrival in a strange country, even though, as must be the case, the sanitary staff precedes the troops, must lead to ventures that ought not to be incurred and might be avoided. And this is the more necessary, as when proper sanitary provision is made in standing camps along the lines of communication, there will be economy of resources, and the observance of the difficult rule to avoid previously-occupied sites may be modified according to circumstances. Each standing camp must have its own permanent sanitary staff and police, working on approved lines to secure uniformity of procedure to which the men become accustomed to conform; in any other case confusion and lack of continuity of policy must ensue.

In regard to the details of that policy a volume might be written, of which, however, the first and last consideration would ever be that of the prevention of the access of the excretory products of man to man; and the difficulties of this task will always be in proportion to the neglect of all the other measures of a complete scheme of hygiene. If anything has emerged clearly from the controversy, it is certainly this, that no one measure, however thoroughly carried out, will secure immunity from the fevers and bowel diseases which disable a force in the field; and this applies equally to water-boiling and to protective inoculation. The key to the problem is, after all, perfect sanitation in all its connotations, and no single device will avail; this alone is the royal road, and there are no short cuts to the end in view. Effective removal and disposal of excreta and refuse products of all kinds, the protection and purification of water-supplies, are the first essentials, the former being at the same time the most effective means of minimising the vehicles of access of the infection, mediately, from man to man. Along with this, and never in default of this, come the organized efforts for the early detection and destruction of infection whether at its original source or in the local *foci* deriving therefrom. Nothing need be added as to the course of procedure in regard to this second line of defence, the recognition and suppression of the disease, which has an indispensable value in supplementing and directing the first, or preventive, measures. To secure the effective disposal of excreta and purity of the water-supplies must, indeed, often tax the resources of the sanitary staff to the utmost, for at every stage of the work everything may be said to depend on human agency which requires not only constant vigilance and supervision, but the intelligent co-operation of the combatant officers and men, both as individuals and as a body imbued with a sense of corporate responsibility. But it is to be remembered that, hitherto, the measures adopted have generally been planned on the worst forms of cantonment methods, which when at their best, as we have seen, are open to damning criticism, and the conditions of a well-organized camp may even favour the abolition of some stages in the process that make for failure, *e.g.*, the standing latrine and the methods of removal in vogue. If it could be ensured that the soldier proceed direct to the place of disposal, the rest would depend on the efficiency of the staff employed at the trenches and this is merely a matter of a trained staff under constant supervision. As between the latrine and pail system (which can only be organized in permanent camps, and which involves all the added risks of subsequent removal and disposal) and the simple trench system, by which disposal is effected at the same time, there can, in the writer's opinion, be little question of the relative advantages, though, indeed, each case must be judged on a careful consideration of the special local circumstances. No one would think of using shallow trenches in this connexion, for apart from the risk of the transport of excreta by the boots and person, the prevention of the transport by dust and of the propagation by flies has to be secured (see remarks on this subject, Chapter VII.). The trenches may well be from 4 feet to 6 feet deep, small planks which can easily be disinfected being supplied for foot-hold, for it is desirable to dispense with seats of any kind, the proper physiological attitude in defæcation, *viz.*, squatting, being adopted for its other obvious advantages in minimising the risk of contact with the excreta. Screens should, of course, be improvised of material capable of ready replacement and re-adjustment, not only to secure privacy but to obviate the transporting effects of wind on any dried excreta that may escape burial, and on paper, etc. The native *mehters* should be on duty behind the trenches which may be arranged back to back in lines to economize space, labour and supervision; these men should patrol a given length of the trenches, one to each double line, and they should immediately cover the excreta after deposit with a layer of earth sufficient to ensure burial; if necessary a simple arrangement for signalling the deposit by the men using the trench could be adopted, and each should be held responsible that the toilet of the trench is duly carried out so far as he is concerned. All trenching sites must be patrolled by an efficient subordinate of the sanitary staff (a trustworthy non-commissioned officer) and be visited regularly by a responsible sanitary officer. Trenches when two-thirds full will, of course, be properly filled in and the earth rammed down and the area marked off or enclosed. It need not be added that every facility should be afforded for access to the trenches both by day and night, the passages thereto being marked and lighted. There is of course nothing new in all this, save as regards the specification of the spirit of vigilance and efficiency which must be brought to its working details,—but that is everything, and no system applicable to field conditions will succeed without it; at the same time all the advantages of simplicity and finality are secured by means with which the men and the staff are well acquainted.

In dealing with excreta and waste which are known, or reasonably believed, to be infective, *i.e.*, from Enteric and Dysentery wards, etc., probably nothing better need be desired than the disinfecting apparatus of Major Cummins, C.M.G., who proved its efficacy in South Africa. It is estimated to be capable of dealing with the excreta, slops, bedpans, etc., of about 100 cases of Enteric Fever or Dysentery during 24 hours; its weight is just under 3 cwt., and, therefore, portable; it requires ordinarily from 50—60 lbs. of coal for a working day of eight hours, a quantity which must be raised to 80 lbs. in windy weather; wood fuel may be used in place of coal. There is evidently scope for the use of fire in other directions and a good apparatus would soon demonstrate its value.

All other refuse, including offal, cooking-waste, and rubbish of all kinds must be collected daily and destroyed by fire ; some may be disposed of on the kitchen fires, the rest should be burnt in rubbish pits set apart in proper places ; carcases of animals must be removed immediately and buried deeply. There should be nothing impracticable in the foregoing suggestions when camp life is exchanged for bivouacs, though modifications in detail may be necessitated.

That the provision of a perfectly pure and palatable water-supply is an ideal to the attainment of which every effort should be exerted no one will deny, but the means thereto are less susceptible of a simple and inclusive definition, unless we regard all water as dangerous without distinction of circumstances. In the latter case a scheme for the systematic sterilization of all drinking-water, and for putting it at the disposal of the men at all times, has much to commend it. Such a scheme has been formulated and advocated with prophetic zeal by Dr. Leigh Canney, and inasmuch as the military medical authorities maintain in practice the necessity of boiling the drinking-water in cantonments, they would apparently have no logical objection to seeing it adopted in the field, provided it be practicable, a matter for careful experiment to decide. We may not overlook the fact in this connexion that, in similar circumstances, sterilization by chemical means may prove its advantages in simplicity and readiness of application ; of these perhaps the most promising are the chlorine and sulphite of soda and the iodine and sulphite of soda methods of Lieutenant Nesfield, I.M.S., as demonstrated at the last Congress of the Royal Institute of Public Health. The protection of the troops when actually engaged in more or less prolonged manœuvres in the field, where the fighting-line extends over several miles and the majority have to depend on their own initiative, calls for special measures in one or other of these directions, if only because the sources of infection among both opposing forces, who may bivouac alternately on the same sites, cannot be known or controlled by the sanitary staff.

In standing camps, the problem is less difficult, the essential aims being to secure a good source and to prevent its contamination, deep-driven artesian wells with distribution by pipes being resorted to where possible ; much might be done by sinking pipes through the bottoms of shallow wells and the requisite apparatus should aways be available. Where more doubtful and dangerous sources of supply have to be depended on (shallow wells, rivers, etc.) they must be protected from encroachment and scrupulously policed, the water being boiled and, whenever possible, served as tea. After all, save in the case of a river, where the men are likely to bathe and the conservancy of which cannot be controlled beyond a short distance, reliance must be placed, not solely but in the first place, on the measures of general sanitation previously alluded to and, in particular, on those which secure the effective removal and disposal of human excreta. In this security the water-supply will share, and where the sanitary control is inadequate, pure water will but cut off one possible avenue of infection, and that not the most important save in very occasional and unusual circumstances. The questions involved in the supply of pure water to the Army in the field are understood to be at present occupying the attention of the highest military authorities who can no longer be in doubt as to their importance; the guiding principles having been discussed, there is the less need to enter into details and our main object is served by entering a *caveat* against the assumption that in securing this one end, the hydra-headed problem of the prevention of Enteric Fever will be solved.

A word in conclusion: recent events have called the nation to a new and clearer view of its responsibilities in respect to all matters that involve the well-being and efficiency of the armed forces of the Empire. Amidst the clamour of discussion which has raged round what most soldiers and politicians deem to be the more important issues,—recruitment, re-organization, re-armament,—one paramount consideration, is too apt to be overlooked. The new order, which public opinion demands, must be founded on a recognition of the facts of our shortcomings in the past, and of the price we have had to pay for them, and no clearer lesson emerges from experience than that which is brought home to all in the record of sickness and mortality which is so largely preventible and which demonstrates the success of our most remorseless foe. In open war we are perfectly familiar with the fact that the losses inflicted by the enemy are trifling compared with those arising from sickness and death, and this among the flower of the nation's manhood and from causes over which we have control. But we are only occasionally at war, and the record in peace from year to year is, in the aggregate, still more accusing and inexcusable; from the purely economic point of view our policy is that of a blind bankrupt, struggling on from day to day and squandering his resources which are ever getting narrower.

The new order, for which we are in travail, must, therefore, recognize that the *prevention* of disease is the primary function of the medical service of the Army, and this involves an almost complete reversal of the policy of the controlling authorities. The page of history is adorned with the names of medical officers who have striven to improve the conditions of the soldier's (and the sailor's) lot and who have so utilized their special opportunities as to confer the greatest benefits on mankind at large, for with them the honour rests of laying the foundations of public hygiene. But this was the fruit of individual talent and energy of the highest order, together with the circumstances in which their lot was cast: it was not due to an organized policy emanating from statesmen responsible to the nation. Such workers are doubtless still available, and are working according to their means, but the conditions are altered in important respects, notably in regard to the complexity and difficulty of the problems which remain to be solved after the first great impression has been made upon the public health by the formulation and recognition of the first principles of hygiene, and by the rise in the standard of living due to economic causes. Moreover, the whole subject has become specialized so that many more labourers are required to cultivate the different fields that now lie open, to co-ordinate the results and to apply them practically. All this demands a recognition of the value, and of the difficulties of the work; more men with special training and a tactical redisposition and re-organization of forces. The position hitherto may be fairly summed up as allowing our men to get sick and keeping a large staff of physicians to cure them—as far as they can; tactics which do not need an epithet to reveal their quality; it is to open your square and ask Fuzzy-Wuzzy to walk in.

It need scarcely be said that the gain will not be confined to the diminution or suppression of any one disease; in attacking the causes of Enteric Fever we are cutting at the root of a noxious growth with many branches. And the gain will not cease with the sphere of the specific infections, for the other categories of disablement, *viz.*, purely functional and degenerative disorders, the predispositions and the penalties, must certainly be affected to our advantage. We need only allude to the benefit which will accrue at the outset from study directed to the differentiation of the "fevers," a "jungle," into which pathways are already being cut.

Large sums of money are being spent on the medical equipment of hospitals—*i.e.*, on the second line of defence—and the doctors' hands are full of cases which reproach our science. This is perhaps more clearly evident in the costly provision rendered necessary for war, which includes a marvellous array of pharmacopæal and other remedies (one had almost written toilet luxuries) and which can hardly be deemed superfluous under present conditions, when, as Sir F. Treves puts it, "we intend to have our 10 *per cent* sick, and we get it." If swords are not to be beaten into plough-shares, it will at least be some consolation to see these huge chemists' shops transformed into receptacles for bandages and first field dressings, and then with a sufficiency of transport we shall be able to dispense with pharmaceutical refinements until the men arrive at the base. We need organized sanitation in the field and an adequate supply of officers to deal with the casualties of pure warfare in the simple preliminary way that has so recently commended itself at the hands of the Japanese surgeons; and with this an efficient transport service. All else is beside the mark at which we ought to aim, but the day for this has yet to dawn. Sir Ian Hamilton (in "*A Staff-Officer's Scrap-Book*") makes some suggestive remarks, in this connexion, which we may ponder with advantage. "In the estimation of the First Army of Japan, England seems absolutely nowhere. Where the officers are at all touched by foreign influence, that influence is either German or French." In the same way we are told that all the army doctors are German by training. "The Japanese invariably adopt the German method instead of the British method whenever there is a difference;" and he adds, "whatever the cause may be, the fact is indisputable that, despite all their wealth and title and British prestige, our doctors have been handsomely worsted in that open-world competition of the nations, where Japan crowns the victor with sincerest flattery." The value of the criticism of our allies is clearly perceived, and however annoying it may be to him to find English ideas slighted, Sir Ian insists vigorously on the significance of such neglect. "The Island Empire," he declares, "offers us a mirror if we would only have the courage to look into it, where we may all see ourselves. Any people who are copied by the Japanese in any department of life may feel fairly secure of being momentarily near the top of the tree in that particular." Accordingly, if we find ourselves not copied, but, on the contrary, carefully neglected, it is a pretty sure indication that there is something amiss with our methods;

and, as we are aware, the Japanese are fully alive to the virtues of our Navy, which renders their discrimination the more valuable in its indications.

After all, it was not a soldier, not a doctor, but a statesman who declared :—"*La bonne santé d'une armée est la première condition de sa puissance.*"

APPENDIX TO CHAPTER X.

Captain Greig, I.M.S., who was deputed by the Secretary of State for India to visit Germany at the end of 1905, in order to study the various methods employed in the campaign against Enteric Fever in that country, has furnished a valuable Report, from which the following verbatim extract has been made, regarding the *technique* now in use for the examination of materials received at the Bacteriological Institutes from suspected cases of the disease. This account may be accepted as the latest and most authoritative statement of the methods of diagnosis which have been developed by long experience in the hands of the most competent experts :—

(1) *Blood.*—The usual Widal reaction, carried out both microscopically and macroscopically. The test is made both with typhoid and paratyphoid B. bacilli. It may be observed that a positive Widal reaction is no proof that the present illness of the patient is typhoid fever, but a reaction which is at first negative, and then becomes positive, is absolute proof.

(2) *Fæces and Urine.*—The examination of these for the presence of *B. typhosus* and *paratyphosus* is all important. Unfortunately we have not yet discovered an ideal method for the detection of *B. typhosus* in fæces ; its recovery from the urine is a simpler matter. We have not got an "enriching" process similar to the peptone water for the detection of the vibrio of cholera. The newer methods, however, are a distinct advance on our older methods, and no doubt further advances will be made.

The following are the methods used :—v. Drigalski and Conradi[1]. Malachite green method of Lentz[2]. Fuchsin agar method of Endo[3]. Caffeïne-fuchsin agar method of Gaehtgens[4].

In the Institutes visited, either the Drigalski-Conradi method alone was employed or in combination with the malachite green method. The Endo method was employed in Diedenhofen, as well as the others. Each method has its advantages and disadvantages, but it is quite certain that rapidity in detecting the typhoid colonies is largely a matter of experience and practice, and an observer who is accustomed to recognise it on one medium may fail to do so on another. The details of the mode of preparation of each of these are given.

(1) *Drigalski-Conradi.—Preparation of medium.*—(i) *Agar preparation:* To three pounds of finely cut horse-flesh add two litres of water. Allow it to stand till next day. The expressed meat juice is boiled for one hour and filtered. Add 20·0 gr. peptone sicca, Witte, 20·0 gr. nutrose, 10·0 gr. NaCl ; boil one hour, now add 70 gr. bar agar, then boil three hours (or one hour in autoclave), render slightly alkaline (indicator litmus paper). Filter, boil half an hour. (ii) *Litmus solution:* Litmus solution (Kubel and Tieman) 260·0 ccm., boil for ten minutes, add milk sugar (chemically pure) 30·0 grm. Boil fifteen minutes. (iii) Add the hot litmus-milk-sugar solution to the liquid agar solution cooled to 60° C. Shake well. Render it again faintly alkaline. The colour of the froth is a good indicator. Add then 2·0 ccm. of a hot sterile solution of 10 per cent. water-free soda, further add 20 ccm. of a freshly prepared solution of 0·1 gr. crystall violet B. (Höchst) in 100·0 ccm. warm water (distilled).

One has now a meat-water peptone-nutrose agar with 13 per cent. litmus and 0·01 per mille crystall violet. This can be poured directly into plates and the remainder kept in 200 ccm. flasks.

(2) *The malachite green "enriching" method of Lentz.—Preparation of the medium.*—The proper preparation to use in malachitgrün (crystall) (Höchst) dilution 1-22,000. Preparation: Three pounds fat-free flesh (oxen), finely divided, macerated with two litres of water for sixteen hours. The extract is expressed, boiled for half an hour, filtered, then 3 per cent. agar added and boiled for three hours ; add to the agar 1 per cent. peptoned 0·5 NaCl, and 1 per cent. nutrose (this may be omitted). This is brought to the litmus neutral point by soda solution with Duplitest paper. Boiled one hour, filtered through linen. The reaction of the finished agar is sometimes distinctly acid. It is filtered into small flasks of 100—200 ccm.

Before the addition of the malachite green, the hot agar is tested by Duplitest paper and so far alkalised with sterile soda solution until the red strip is distinctly red-violet. This reaction point corresponds in agar, without nutrose, to an alkalescent degree of 1·8 per cent. normal soda below the phenolphthalein-neutral point ; if the agar contains nutrose, which remains neutral towards litmus and bacteria, then the alkaline reaction corresponds to 3·5 per cent. normal soda solution below the phenolphthalein point.

To 100 ccm. of the hot agar 1 ccm. of a 1-220 solution malachite green (the solution keeps good for ten days) is added, *i.e.*, agar contains 1-22,000. By this concentration of malachite green (crystall) the growth of the usual kinds of *B. coli.* as well as many alkali-forming organisms, is greatly diminished and practically prevented. The *B. typhosus* growth is also diminished, but only so far that after twenty-four hours the colony can be recognised with the naked eye, the size of a particle of sand, whilst, after a longer period in the incubator, in two to four days, larger, stronger colonies appear which colour the agar yellow.

The finished agar is poured at once into Petri dishes in 2 mm. thick layers. The dishes are well dried.

(3) *The fuchsin agar method of Endo.—Preparation of the medium.*—In an enamel pot put two litres of water (tap), 20·0 gr. Liebig's meat extract, 20 gr. peptone sicca, Witte, 10·0 NaCl, and 80 gr. bar agar. Boil, filter, neutralise. Add 10 gr. *chemically pure* milk sugar and 10 ccm. of 10 per cent. crystallised fuchsin in 96 per cent. alcohol. Then the medium becomes dark red in colour. Now add 25 ccm. of a 10 per cent. sodium sulphite solution. The medium becomes gradually discoloured, but only completely so when the agar is stiff. Sterilise in small tubes for thirty minutes. Pour into plates.

4. *The caffeïne fuchsin agar method of Gaehtgens.—Preparation of the medium.*—As a result of his experiments, he found that an addition of 0·33 per cent. chemically pure caffeïne to Endo's medium (*vide* previous preparation), which had an alkalinity equal to 1·5 per cent. normal KOH below the neutral point of phenolphthalein, markedly increased the value of the medium as a means of detecting *B. typhosus* in the stool.

Endo medium, prepared in exactly the same way as described by himself, is liquified, made alkaline to the required degree, and the required amount of caffeïne added.

In all these methods attempts are made, with more or less success, to check the growth of members of the coli group, and to encourage the development of the *B. typhosus* and *para-typhosus*. In the Drigalski and Conradi method crystall violet is used; in the Lentz method, malachite green; in the Endo, fuchsin; and Gaehtgens, caffeïne. At the same time, the typhoid colonies are differentiated from the coli group by a colour reaction. In Drigalski the typhoid colonies are blue and the coli red. In the Endo the coli colonies turn bright red, whilst the typhoid colonies are colourless. In both cases the fact that *B. coli* produces acid in presence of milk sugar is made use of by in the one case, litmus, and the other, decolourised fuchsin, a colour reaction being thus obtained in both cases.

Malachite green checks the growth of both coli and typhoid very markedly, but more especially coli. Accordingly, when a stool is planted out on such an agar plate, it may not be possible at the end of twenty-four hours to detect any colonies of typhoid. Lentz has found, however, that if such a plate is flooded with normal salt solution and gently rocked and then allowed to stand for a few minutes, the delicate typhoid colonies diffuse themselves in the solution, whilst the solid coli colonies sink to the bottom, so that if a little of this fluid is plated out on Drigalski plates, practically a pure growth of *B. typhosus* or *para-typhosus* may be obtained. In practice, it is found that the *B. para-typhosus* is readily "enriched" in this way, but the *B. typhosus* not to the same extent.

Having thus seen the method of preparation of the different culture media and principles of their use, it is next necessary to consider the method of preparation and insemination of the plates with the fæces and urine. The following are the steps :—

(1) *The preparation of the plates.*—In this investigation it is more convenient to use a larger size of Petri dish than that generally used. It should be from 15 to 20 centimetres in diameter. About 20 to 25 cubic centimetres of the medium is poured into each plate. The plates are allowed to remain open until all the steam has evaporated and the agar is quite stiff. It is essential that the surface of the plates should be quite dry and firm. Contamination by air-organisms does not occur on account of the aniline dye present in the culture media.

(2) *The preparation of the fæces.*—The fæces are thoroughly mixed with a small quantity of sterile normal salt solution. Then, when one malachite green plate is used in combination with two Drigalski plates, about 0·5 ccm. of the mixture is placed on a green plate. This amount may also be used with the caffeine-Endo, but with the Drigalski plates alone a much smaller amount, about one or two loopfuls, is sufficient.

In the case of urine, several drops are placed on the green plates, on the Drigalski plates one drop is sufficient.

Having thus got the prepared material on the first plate, the next step is the smearing. This is done in the same way, whether green and blue, or all blue, plates are used.

(3) *Smearing of the plates.*—A sterile glass rod (spatula), bent at right angles, is used.

The material on the first plate is thoroughly smeared by rubbing the glass spatula, as it is called, in all directions over the surface of the agar. Then, without sterilising it, the same spatula is rubbed over the surface of a second plate, and then over a third and fourth. After the smearing, the plates are allowed to stand open till quite dry. The plates are then placed in the incubator at 37° C., and left there for twenty to twenty-four hours. At the end of this period the next step is—

The examination of the colonies.—It will be convenient to state briefly the characters of the colonies on the different media already mentioned.

(1) *Drigalski-Conradi.*—By this method the first plate is so overgrown, that it is useless for further examination. The second, third, and fourth, however, are carefully inspected. It is very desirable to use a hand lens for this purpose; also to direct the plate, so that the light falls from a wall, not directly from the window, as a better contrast between the colonies is obtained. After a good deal of practice, it is possible to recognise immediately a colony of *B. typhosus* on the plate even if only a single one exists, but, at first, it takes a considerable amount of time, because a large number of colonies are found which closely resemble those of *B. typhosus*, and it is, therefore, necessary to test each of them according to the methods described later. Broadly stated, the *B. coli* colonies are more or less red in colour, not transparent, and from 2—6 millimetres in diameter, whilst the *B. typhosus* colonies have a diameter of from 1—2 millimetres. The colour is blue with a dash of violet; they resemble dew drops.

(2) *Combined malachite green and Drigalski method.*—As will be remembered, the first plate in this method was malachite green agar, and the second and third Drigalski Conradi. At the end of twenty hours the second and third plates are examined, and present the same characters as noted above. If typhoid colonies are found on these plates then the investigation is finished, but if they are not, it is possible by a further procedure to detect them, and this is the special merit claimed for this method. The procedure is this: the green plate is flooded with sterile normal saline and gently rocked, and then allowed to stand for a few minutes. By this means it is found that the more delicate typhoid and para-typhoid colonies readily diffuse themselves in the liquid whilst the heavier coli colonies, whose growth has been remarkably inhibited by the malachite green, sink to the bottom. The glass spatula is then dipped in the salt solution and rubbed on one or two Drigalski-Conradi plates, which are placed in the incubator at 37° C. for

twenty hours, and are then examined in the usual manner. This method of "enriching" gives very good results with *B. paratyphosus*; the *B. typhosus* is not "enriched" to the same extent, but still it is an additional means of detecting this organism, and in the hands of Lentz has yielded good results

(3) *Endo method.*—Here all the coli colonies are bright red at the end of twenty hours, and, therefore, very easily separated. The typhoid colonies are colourless and very transparent. A stool plated on this medium gives a very striking picture, and the use of this method does not strain the eyes to the same extent as the blue plates. If a very large number of coli organisms are present the plate is liable to become entirely red, and this interferes with the examination of the typhoid colonies. On the whole, this medium appears a very useful one for the separation of *B. coli* and *typhosus*.

(4) *Gaehtgens caffeine-fuchsinn agar.* The appearance is essentially the same as that on the Endo plates, but the growth of *B. coli* is markedly inhibited.

Having thus seen the general appearance of the colonies, the next step is :—

The identification of suspected typhoid colonies.—In practice, this is done as follows :—(1) A portion of the colony is touched with a very fine platinum needle and placed in a drop of highly active serum, in dilution 1—100, on a slide and carefully mixed; at the same time a control should be made with a drop of normal saline solution placed alongside. The agglutination, if it occurs, may be observed with a hand lens or low power of the microscope. Both typhoid and para-typhoid sera are used. In this way a large number of colonies can be rapidly examined. Should complete agglutination occur, then the remainder of the colony is inoculated into tubes containing various nutrient media. From the academic point of view, a considerable number of these are required, but, in practice, it is found that about three amply meet all the necessities, of which ordinary agar slope, litmus whey, and neutral red agar, or grape sugar, are most commonly used.

The following is a complete list of the different media with the methods of preparation :—

(*a*) *Barsikow milk sugar.*—Made thus: (i) 1 gr. nutrose, 0·5 gr. NaCl, aqua distill. 100 cc. Sterilise; filter several times to clarify. (ii) 5 cc. litmus solution (Kubel and Tieman), 1 gr. milk sugar or grape sugar or mannite, maltose, etc. Sterilise six to eight minutes. Cool to 60. C. Mix (i) and (ii). Sterilise for ten minutes on three successive days. (*b*) *Mannite,* as above. (*c*)

Barsikow's grape sugar, as above. (*d*) *Litmus whey*: 500 cc. milk; add 10 to 12 ccm. N/1 solution HCl to precipitate casein. Neutralise with soda solution. Boil one to two hours. Let the precipitate fall to the bottom. Take 100 ccm. of fluid and add 5 ccm. litmus solution. Place in tubes, sterilise two to three hours at 100. C. (*e*) *Neutral roth agar*: agar 2 per cent., grape sugar 0·3 per cent., neutral roth solution 1 ccm. (saturated watery solution of Ehrlich's neutral roth). Mix; sterilise.

The following table shows the effects of growth of *B. typhosus*, *B. coli com.*. *B. para-typhosus*, A. and B., *B. dysentery* (Shiga), and *B. Gaertneri* in various media :—

—	Bouillon Gas tubes.	Mannite Bouillon.	Milk.	Barsikow's Milk Sugar.	Barsikow's Grape Sugar.	Litmus Whey.	Neutral Red Agar.
Control ...	No gas ...	Blue ...	Unaltered	Blue ...	Blue .	Violet ...	Dark red. No gas.
B. Typhosus ...	No gas ...	Red. No gas.	Unaltered	Unaltered.	Red ...	Slightly red.	No change. No gas.
B. Coli Com....	Gas ...	Red. Gas	Coagulated	Red. Coagulated.	Red. Coagulated.	Red ...	Fluorescent Gas.
B. Paratyph. A.	Gas ...	Less gas. Red.	Unaltered	Unaltered.	Slight red. Coagulated.	Slight red.	Fluorescent Gas. Less than paratyphoid B.
B. Paratyph. B.	Gas, slight	Less gas. Red.	After some weeks becomes yellow and strongly alkaline.	Unaltered.	Slightly red. Coagulated.	After 14 days forms a blue scum.	Ditto.
B. Shiga Dysentery.	No gas ...	No gas. Blue.	Unaltered	Unaltered.	Bright red.	Unaltered.	Unaltered.
B. Gaertneri...	Gas, slight	Red. Gas	Unaltered	Slight red.	Red. Coagulated.	Unaltered.	Gas. Fluorescent.

Should the agglutination be positive in 1—100 dilution of serum, and the organism give characteristic reactions in the various media, the diagnosis of typhoid or paratyphoid, as the case may be, can then be made. Only in exceptional cases is it necessary to perform the Pfeiffer experiment.

The above is a description of the routine examinations made at the Institutes. In addition to the urine and fæces it may, occasionally, be necessary to examine expectoration from the lungs, pus, and *post-mortem* material. The procedure is exactly similar to that adopted in the examination of fæces.

To determine the presence of typhoid bacilli in the blood, it is necessary to take about 5 cc. from a vein and add to it a large quantity of sterile bouillon to neutralise the bactericidal substances present in the blood.

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